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DESIGN CRITERIA FOR SYSTEMS EFFECTIVENESS

Donald R. Sartor
Walter J. Robbins
Robert F. Tommoney
Federal Electric Corporation

TECHNICAL REPORT NO. RADC-TR-67-278
August 1967

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Rome Air Development Center
Air Force Systems Command
Griffiss Air Force Base, New York

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AFLC, GAFB, N.Y., 17 Oct 67-103

FOREWORD

This technical report represents the results achieved by Federal Electric Corporation, Paramus, New Jersey in conducting a study and investigation of Design Criteria For Systems Effectiveness. The study was performed under Contract AF30(602)-4062, Project 5519, Task 551907 during the period from March 1966 through April 1967.

This project was performed under the overall guidance of C. Butler, Manager of the Equipment and Systems Evaluation Branch of the Engineering and Support Services Division. The study was supervised by R. F. Tommaney, Supervisor of the Analysis and Development Section. The Federal Electronic project engineer was D. R. Sartor; principal technical contributors were W. J. Robbins and A. Castellon.

The project engineer was Anthony Coppola, Rome Air Development Center, EMERS, Griffiss Air Force Base, N.Y. 13440.

This technical report has been reviewed by the Foreign Disclosure Policy Office (EMLI). It is not releasable to the Clearinghouse for Federal Scinetific and Technical Information because it contains information embargoed from release to Sino-Soviet Bloc Countries by AFR 400-10 and AFSCM 200-2 "Strategic Trade Control Program."

This technical report has been reviewed and is approved.

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ABSTRACT

The achievement of optimum Systems Effectiveness in the operational environment is dependent on the proper consideration and implementation of a number of events, starting from the very conception of the system and proceeding through the acceptance of the system in the field. A need existed for the development of an organized approach which could be used as the basis for ensuring that these events are adequately considered and performed on a timely basis.

The study described herein was undertaken for the purpose of identifying those events which influence Systems Effectiveness and the determination of the relationships of these events. This information was organized in a manner which provides cognizant personnel with the criteria necessary for achieving optimum Systems Effectiveness. Major emphasis was placed on criteria relating to the design of systems since this is the area in which the majority of events influencing Systems Effectiveness must be implemented. However, events associated with system development, production and acceptance were also considered since they have a direct impact on operational effectiveness.

An integral part of this report is the Requirements for a Systems Effectiveness Program. These requirements, based on the entire Systems Effectiveness study, provide uniform criteria for development of Systems Effectiveness Programs and provide a model for the preparation of Systems Effectiveness Program Plans.

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EVALUATION

1. The objectives of Contract AF30(602)-4062 were the determination of the disciplines related to system effectiveness, the categorization of environmental influences on system effectiveness, and the provision of a model system effectiveness plan. RADC-TR-67-278, the final report of the contract, provides the following:

a. A delineation of 14 disciplines which influence system effectiveness and the establishment of responsibilities for these disciplines among the various functional activities of an engineering agency. The report presents a further delineation of particular tasks to be performed in each discipline by each functional activity and provides priorities and scheduling guidance.

b. A delineation of the natural and man-made environmental factors affecting system effectiveness and a method for selecting the significant factors for a specified system. Further, the detrimental effects of the factors are described.

c. A model system effectiveness program plan which neither assumes nor precludes the specification of quantitative system effectiveness requirements.

2. The report, therefore, meets the objectives of the contract and provides a basic reference document for system managers. The evaluator believes the report will be of great value in guiding the efforts of system project officers and their industrial counterparts, providing a framework for assuring the consideration of all factors pertinent to the effectiveness of the systems under their responsibility.

3. It must be noted, however, that the report deals only with ground electronic systems, and is nonquantitative in its treatment. Subsequent studies will extend the scope of coverage and will provide the quantitative relationships between the identified factors and system effectiveness.

Anthony Coppola
ANTHONY COPPOLA
Chief, System Effectiveness & Support Section
Reliability Branch

SECTION I
INTRODUCTION

1. OBJECTIVE

The objective of this study was the development of an organized approach, which could be used by planners and designers, for the purpose of optimizing Systems Effectiveness of ground electronic equipment and systems. This required preliminary development effort associated with systems effectiveness design criteria and resulted in the formulation of a document entitled, "Requirements for a Systems Effectiveness Program." This document provides uniform criteria for the development of Systems Effectiveness Programs as well as guidelines for preparing Systems Effectiveness Program Plans.

In meeting the objective, Federal Electric Corporation answered the following questions:

1. Which specific Abilities and specific events (Subabilities and Related Factors) should system planners and system designers focus their primary attention on during the system development cycle?

2. Where should the abilities and events be treated?

3. What order of importance should be followed in treating these events?

4. When should the specific events be treated?

5. How can Systems Effectiveness be improved?

6. What Environments (natural and induced) affect Systems Effectiveness?

7. How do Environments affect Systems Effectiveness?

The purpose of the analysis of abilities, events, and environments was to provide the system planners and designers with a means: 1) of identifying the abilities and related events that influence Systems Effectiveness and the environmental problems

associated with systems; 2) to determine relationships between abilities in the context of a typical system development organization and to provide knowledge of environmental conditions and their effects on system performance; 3) to develop the requirements for a Systems Effectiveness Plan which will ensure improvement in Systems Effectiveness; and 4) to indicate which environmental effects should be design controlled preparatory to final system design and implementation.

2. SCOPE

It is conceivable, at present, to specify and to quantitatively predict effectiveness for some types of Air Force Systems, however, design criteria to ensure an acceptable level of Systems Effectiveness have not been available up to the present. This study resulted in the development of an integrated approach to Systems Effectiveness for ground electronic systems. Systems Effectiveness was viewed as a dependent function of Constituent Abilities, Subabilities, Related Factors, and environmental considerations. The scope of effort did not provide for the treatment of cost effectiveness, although cost effectiveness must be a consideration in the total evaluation of a system.

After evaluating the input required for the study, Federal Electric Corporation obtained data on the following types of operating ground electronic systems: Communication, Radar, Computer, and Missile Support. The program was restricted to a study of these types of systems. Some of the operating systems from which systems effectiveness data were collected were: 465L Strategic Air Command Control System; 486L Mediterranean Communication System; Western Test Range; and Cape Kennedy Merritt Island Launch Area (Instrumentation and Support Services).

Federal Electric Corporation also obtained a limited amount of systems effectiveness data from contractors with responsibility for other ground electronic systems.

SECTION II
TECHNICAL DISCUSSION

1. INTRODUCTION

This section of the report contains a description of the results of the study, investigation, and analysis leading to the development of criteria and guidelines for Systems Effectiveness. Data inputs were selected to provide the most meaningful systems effectiveness outputs. Information was obtained from two major sources, technical literature appropriate to Systems Effectiveness and a systems effectiveness field survey. The field survey data were user data obtained from personnel who have had responsibility for operating systems. The survey included form completion as well as personal interviews with operating personnel. These survey data reflected actual system problems that occur daily and result in reduced Systems Effectiveness.

The approach used in this study was to proceed from the actual problems in the field (substantiated by data) to development of criteria and guidelines to prevent or minimize the adverse affect of these problems on Systems Effectiveness. Based on the analysis and evaluation of technical literature and field data, criteria and guidelines were formulated for systems effectiveness improvement.

The investigation and results described in this section of the report were used as an input in the development of Requirements for a Systems Effectiveness Program which contains uniform criteria and guidelines that should be applied in the development of a Systems Effectiveness Program and a Systems Effectiveness Program Plan.

2. DETERMINATION OF SYSTEMS EFFECTIVENESS DATA INPUTS

During preliminary investigation of systems effectiveness data sources, technical literature and data on operating systems were evaluated. The preliminary evaluation of these data resulted in the following conclusions:

1. An extensive literature search would be necessary to locate applicable information and data.

2. The operating system data had to be user oriented.

3. A special form would have to be developed specifically for the collection of systems effectiveness user data.

4. Personal follow-up (interviews with personnel who completed a systems effectiveness form) would be needed to supplement the user data to be collected by means of the new form.

5. The approach to be used during the study had to permit tracing back from factors (based on user data) that cause systems ineffectiveness to events that will prevent these factors from occurring.

a. Technical Literature Search

The literature search began early in the program concurrent with development of the Systems Effectiveness Survey Form. The literature search was conducted to supplement the results of a systems effectiveness survey which was conducted later in the program.

Sources of technical literature included such documents as the Weapon Systems Effectiveness Industry Advisory Committee (WSEIAC) final report, Annals of Reliability and Maintainability (5th Reliability and Maintainability Conference Proceedings), and Proceedings of the First EIA Conference on Systems Effectiveness. A complete listing of all documents researched are included in the References at the end of the report. The literature search resulted in a considerable amount of pertinent information which was used to augment user data obtained from the survey.

b. Operating System Data

Pertinent operating system data were collected to aid in the identification of the factors that comprise Systems Effectiveness. Operating system data, which was user oriented, were collected on Communication, Radar, Computer, and Missile Support systems. User data were collected to identify specific factors that do now or have in the past contributed to systems ineffectiveness. The user data served as feedback of the qualitative experience of personnel assigned to operating systems. Data oriented to the abilities that affect Systems Effectiveness and data oriented to the environments that affect Systems Effectiveness were collected.

c. Systems Effectiveness Field Survey

It was recognized early in the program that it would be necessary to devise a new field survey form to collect the type of data (user data) required to develop an integrated approach to Systems Effectiveness. Federal Electric Corporation developed a Systems Effectiveness Survey Form as a means of obtaining user data on operating systems. This form is presented in Appendix I. The numerical values appearing after each Specific Factor on the form represent a composite of all responses received. The major criteria for inclusion of a factor on the form was that it had to be potentially capable of degrading Systems Effectiveness. The survey form was developed using literature search data and engineering judgment as inputs. The format used (quick response check-off) did not provide for written comments, since interviews were scheduled with the personnel responding to the survey. These interviews provided the opportunity for obtaining additional data. A cover letter was attached to the forms which briefly explained the nature of the Systems Effectiveness Program and how user personnel could contribute to the program.

The following example is given in order to provide insight into the typical thought process used in recording information relating to each of the factors contained on the survey form. The example is related to Specific Factor, Mission Tolerances - Narrow in Group I, Mission Oriented Factors, found on page 60 of the survey form shown in Appendix I.

A typical respondent would make the following mental evaluation in order to properly respond:

1. What is the mission goal for my system?

2. Do I have any knowledge of mission tolerances for the system? If answer is no, No Knowledge of this Factor, would be checked. If answer is yes, proceed.

3. Is this specific factor applicable to my system and mission? If answer is no, Factor Not Applicable, would be checked. If answer is yes, proceed.

4. Do I have any personal experience regarding the adverse affect of Narrow Mission Tolerances on the effectiveness of my system's mission? If answer is no, None, would be checked. If answer is yes, proceed.

5. Has this adverse effect been: Minimal, Significant, or Critical? Appropriate effect would be checked.

The survey data were analyzed to provide a meaningful input based on user experience. A rank order approach was used to analyze the results of the systems effectiveness survey data. A qualitative summary of the survey data is presented in Appendix II, Results of Rank Order Analysis of Systems Effectiveness Survey. Each individual responding to the survey would make similar evaluations of each specific factor on the form and respond according to his own personal experience.

The survey forms were distributed to program managers of major ground electronic systems, who then distributed the forms to key personnel within their organization. Completed survey forms were returned from ITT for the 486L Mediterranean Communication System; 465L Strategic Air Command Control System; Western Test Range;

Cape Kennedy — Merritt Island Launch Area (Instrumentation and Support Services); Marshall Space Flight Center — Quality, Reliability Assurance Laboratory; European Tropo Army; and Early Warning System. Additional completed survey forms were returned from the Electronic Systems Division, AFSC, for the 473L Headquarters USAF Command and Control System; 496L Space Track System; 474L Ballistic Missile Early Warning System (BMEWS); and 487 Survivable Low Frequency Communications System.

d. Personal Interviews

Interviews were conducted at operating system locations with system personnel who had previously filled out survey forms. This follow-up effort was implemented to supplement the data obtained by means of the survey form. Results from the personal interviews were both encouraging and informative. The majority of key people interviewed considered the systems effectiveness survey comprehensive and a significant first step in the development of systems effectiveness design criteria. A considerable amount of supplementary data were obtained during the personal interviews. These data, in addition to supplementing the survey form data, provided an input to the development of Check Lists for Systems Effectiveness Improvement. These check lists are discussed in paragraph 5 of this section.

3. INVESTIGATION AND DEVELOPMENT OF CRITERIA FOR SYSTEMS EFFECTIVENESS

The investigation and development of criteria for Systems Effectiveness were divided into two principal areas. The first area concerned the investigation of Constituent Abilities or Disciplines (e.g., reliability) impacting on Systems Effectiveness as well as the events (Subabilities and Related Factors) that must take place to ensure Systems Effectiveness. The second area of investigation concerned environments and their affect on Systems Effectiveness. Details of the study and investigation carried out in these areas as well as the results achieved are presented in the following paragraphs.

4. DETERMINATION OF ABILITIES RELATED TO SYSTEMS EFFECTIVENESS

Abilities (Availability, Dependability, and Capability) which influence Systems Effectiveness have been documented in the Weapon Systems Industry Advisory Committee (WSEIAC) Final Report. Federal Electric Corporation expanded these so as to include all of the Constitutent Abilities that make up each ability in order to develop an integrated and organized approach to Systems Effectiveness. This was accomplished by developing the detailed elements which comprise each of the three abilities. Each ability was determined to be composed of certain Constituent Abilities (e.g., Reliability) which are major systems effectiveness disciplines. Each Constituent Ability was in turn viewed as being composed of events termed Subabilities and Related Factors. These terms are defined as follows:

1. Constituent Ability — a discipline related to the success of a mission (e.g., Reliability).

2. Subability — an event that must be performed for the distinct purpose of ensuring that a certain goal be achieved. A subability is directly related to a constituent ability (e.g., redundancy is a subability of reliability).

3. Related Factor — an event that must be performed for the distinct purpose of ensuring that a certain goal be achieved. A related factor is indirectly related to a constituent ability (e.g., field data are a related factor of reliability).

a. Identification of Constituent Abilities, Subabilities, and Related Factors

Based on an analysis of the results of the literature search and the results of the systems effectiveness survey, Constituent Abilities, Subabilities, and Related Factors were identified. Shown in Figure 1 are all of the Constituent Abilities, Subabilities, and Related Factors that were identified during the study.

b. Relationship of Constituent Abilities, Subabilities, and Related Factors to Systems Development Organizational Functions and Activities

The responsibility for accomplishing events related to each Con-

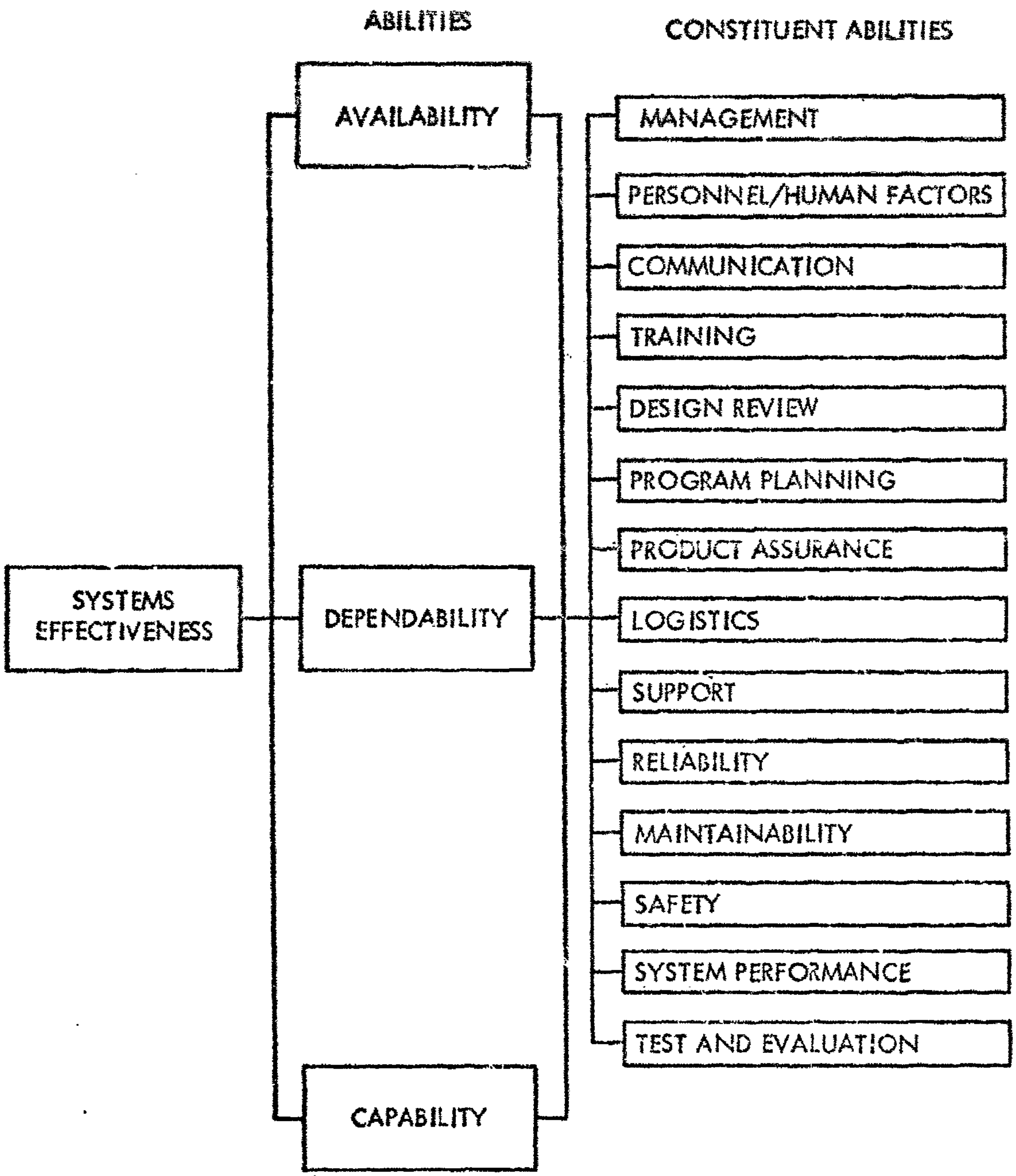


Figure 1. Abilities, Constituent Abilities, Subabilities and Related Factors Comprising Systems Effectiveness

MANAGEMENT

Subabilities

Contract Requirements
Administrative
- Organization
- Control
- Planning
- Scheduling
- Coordination
- Procedures
- Capability

Operational Requirements
Technical Capability
Design Integrity
Management Qualifications
Contract Management
Materiel Management
Security Requirements
Discrepancies
Configuration Management
Corrective Action
Government Management Personnel
Technical Inputs and Outputs from all Functional Activities
Training Capability
Security Requirements
Problem Areas
Government Operations Personnel

Related Factors

Administrative Delays
Reports/Data
Management Technique Development
Management-Employee Relationships
Trade-Offs
Corrective Action

Figure 1. Continued

COMMUNICATION

Subabilities

Government-Contractor Communication
Written Communications
Oral Communications
Government Standards, Procedures & Formats
Standard Operating Procedures
Procedures
- Overall Mission
- Operating
- Maintenance
- Storage
- Test
- Inspection
- Training
- Installation

Failure Data Collection
Extra-Site Communications
Intra-Site Communications
Inter-Site Communications
Operations and Technical Manuals
Technical Input for Procedures
- Overall Mission
- Operating
- Maintenance
- Test
- Inspection
- Training
- Storage

Input for Technical Manuals

Figure 1. Continued

PROGRAM PLANNING

Subabilities

Mission
Mission Elements
Time Phasing
Milestones
Task Description
Planning Procedures
Goals
Requirements
Constraints
Trade-Offs
Manufacturing Support
Field Support
Corrective Action
Assessment and Verification
Program Plans
- Task Descriptions
- Time Phasing
- Milestones

Contract Requirements
Capability
Installation Requirements
Organization
Procedures
Schedules
Controls
Security Requirements
Configuration Control
Discrepancies

Related Factors

Responsibility for Task Accomplishment
Reports/Data
Data Feedback
Specifications and Standards
Mathematical/Statistical Analysis

Figure 1. Continued

PERSONNEL/HUMAN FACTORS

Subabilities

Completeness
Personnel Requirements
Type of Personnel
- Administrative
- Operations
- Logistics
- Maintenance
- Support
- Engineering

Number of Personnel
Turn-Over Rate
Conciseness
New Personnel
Health
User Review
Government-Contractor Relations
Type of Personnel List
Personnel Selection
Human Error
Man-Machine Interfaces
Composition
Accessibility
Work Space
Artificial Environments
Lighting
Updating
Noise
Skill Levels
Printing
Requirements
Constraints
Corrective Action
Clarity
Inherent Danger
Packaging/Binding
Hazards
- Mechanical
- Electrical

Contract Requirements
Program Plan Requirements
Accuracy
Schedules
Specifications and Standards
Sources of Information

Related Factors

Personnel Development
Personnel Adaptation
Extended Work Schedules
Working Conditions
Motivation
Housing
Government-Contractor Relations
Isolation Factor
Devices
- Warning
- Signalling
- Displays
- Controls

Work Load
Demands
- Physical
- Mental

Janitorial Services
Human Engineering Program Plan
Design Changes
Discrepancies

Figure 1. Continued

SYSTEM PERFORMANCE

Subabilities

Mission Goals
System Modifications
Inputs
Outputs
Modes of Operation
Sensitivity
Human Error
Catastrophic Failures
Degradation
Vulnerability
Highly Specialized Mission
- Accuracy
- Frequency
- Length

Routine Mission
- Accuracy
- Frequency
- Length

Mission
- Accuracy
- Frequency
- Length

Tolerances
- Mechanical
- Mission
- Pre-Launch
- Post-Launch
- Electrical
- Thermal
- Instrument
- Cooling System
- Frequency

Prime Power
Electromagnetic Interference
Government Furnished Equipment
Transients
Power Supply
Prime Power Fluctuation
Electrical Interference
Signal Bandwidth
Signal Frequency
Noise Figure
Propagation Changes
Compatibility
Range
Weight
Cost
Recovery Time
Electronic Countermeasures
Recalibration
Government Furnished Equipment
Corrective Action
Contract Requirements
Modes of Operation
Compatibility
High Precision
Data Recovery Time
Electromagnetic Interference
Capacity

Related Factors

Cost Information
Production
Purchasing
Reports/Data
Alternate Action
Flexibility
Specifications and Drawings
Information Security
Technical Inputs for Purchasing
Loss of Signal
Operations and Technical Manuals

Figure 1. Continued

SUPPORT

Subabilities

Contract Requirements
Compatibility
Facilities
Site Selection
Installation Requirements
Buildings
Storage
Installation
Installation Procedures
Documentation
Corrective Action

Related Factors

Site Real Estate
Maintenance
Program Plan

Figure 1. Continued

RELIABILITY

Subabilities

Requirements
Modes of Operation
Redundancy
Derating
Tolerances
- Electrical
- Mechanical
- Thermal

Shock
Vibration
Electromagnetic Interference
Constraints
Critical Elements
Hardware
- Interfaces
- Standard Parts
- Printed Wiring
- Microelectronics

Test/Demonstration
Performance
Corrective Action
Contract Requirements
Program Plan Requirements
Schedule
Design Integrity
Problem Areas

Related Factors

State-of-the-Art Devices
Discrepancies
Programs
- Reliability Program Plan
- Field Failure Feedback Program

Failure Mode and Effects
Field Failure Data
Reliability Prediction
Design Changes
Air Conditioning

Figure 1. Continued

MAINTAINABILITY

Subabilities	Related Factors
Requirements	Standardization
Maintenance Philosophy	Continuous Operation Constraints
Constraints	Discrepancies
Corrective Action	Programs
Maintenance	Maintainability Program Plan
Depot	Maintenance Data Feedback Program
Field	Maintenance Data
Organizational	Maintainability Prediction
Accessibility	Design Changes
Localization	Troubleshooting Techniques
Test Points	Administrative Delay Time
Packaging	Safety Hazards
Interchangeability	Spare Parts
Overhaul Requirements	Technical Capability
Calibration Requirements	Documentation
Replaceability	Maintenance Procedures
Mounting Requirements	Technical Manuals
Inspectability	Routine Paper Work Requirements
Handling Requirements	
Storage Requirements	
Test/Demonstration	
Field Performance	
Contract Requirements	
Program Plan Requirements	
Schedule	
Design Integrity	
Problem Areas	

Figure 1. Continued

PRODUCT ASSURANCE

Subabilities

Requirements
Constraints
Corrective Action
Contract Requirements
Program Plan Requirements
Schedule
Workmanship
Engineering Drawings and Specifications
Procurement Specifications
Purchase Orders
Test/Demonstrations
Inspections
- Receiving
- In Process
- Installation
- Final

Periodic Quality Audits
Vendor Surveillance
Material Testing
Test and Demonstration

Related Factors

Design Changes
Product Assurance Program Plan
Configuration Control
Discrepancies

Figure 1. Continued

TRAINING

Subabilities

Training Level
Curricula
Instructors
Material
Special Training Devices
Specialized Equipment Training
Contractor Training
Procedures
Number of Trained Personnel
Training Level Requirements
Contract Requirements
Training Evaluation Personnel Information

Related Factors

Concepts
Training Equipment
Facilities
Plans
Personnel Improvement Program

Figure 1. Continued

DESIGN REVIEW

Subabilities

System Considerations
Conceptual Design
Electrical Design
Mechanical Design
Safety Factors
Compatibility
Subcontract Items
Standardization
Frequency of Review
Duration of Review
Packaging
Reliability
Maintainability
Circuit Considerations
Component Part Selection
Component Part Application
Producibility
Materials and Processes
Design Disclosure Format
Configuration Control
Corrective Action
Standardization
Frequency of Review
Personnel Participating

Related Factors

Test Procedures
Electrical Interference
Electrical Interfaces
Discrepancies

Figure 1. Continued

SAFETY

Subabilities

Hazards
- Mechanical
- Electrical

Inherent Dangers
Protection Devices
Warning Devices
Special Electronic Devices
Requirements
Constraints
Corrective Action
Safety Devices and Shields
Safety Controls
Accident/Incident Reports
Contract Requirements
Program Plan Requirements
Schedule
Safety Control

Related Factors

Safety Deficiencies
Discrepancies
Safety Data
Safety Engineering Plan
Design Changes

Figure 1. Continued

LOGISTICS

Subabilities

Facilities
Sources of Supply
Spares
Turn-Around-Time
Storage
Handling
Transportation
Hardware
- Standard Parts
- Packaging

Contract Requirements
Delivery
Standard Parts
Frequent Document Changes
Supply of Documents
Government Furnished Equipment

Related Factors

Logistics Data
Delays
- Purchasing
- Administrative
- Military

Inventory
Maintenance Philosophy
Contractor Maintenance
Interchangeability
Purchasing Support
Maintenance Philosophy
Selected Special Parts
Custom Requirements
Procedures
- Requisition
- Storage

Breakage in Transit
Logistics Program Plan

Figure 1. Continued

TEST AND EVALUATION

Subabilities

Test Specifications
Test Standards
Test Procedures
Requirements
- Test
- Calibration

Category I, II, III System Testing
Part Testing
Tests
- Environmental
- Test-to-Failure
- System Storage
- Handling Tests
- Tactical Usage Tests

Contract Requirements
Requirements of all Program Plans
Test Configuration
Test Sequences
Simultaneous Testing
Category I Tests
Category II, and III Tests
Schedules
Test and Evaluation Program Plan
Calibration
Tests/Demonstrations (Category I, II, III)
- System Performance
- Reliability
- Maintainability
- Product Assurance
- Safety
- Installation
- Human Engineering
- Storage and Handling
- Tactical Usage Tests

Results
Category I Test Report
Category II and III Test Reports
Test/Demonstration
- Schedules

Figure 1. Continued

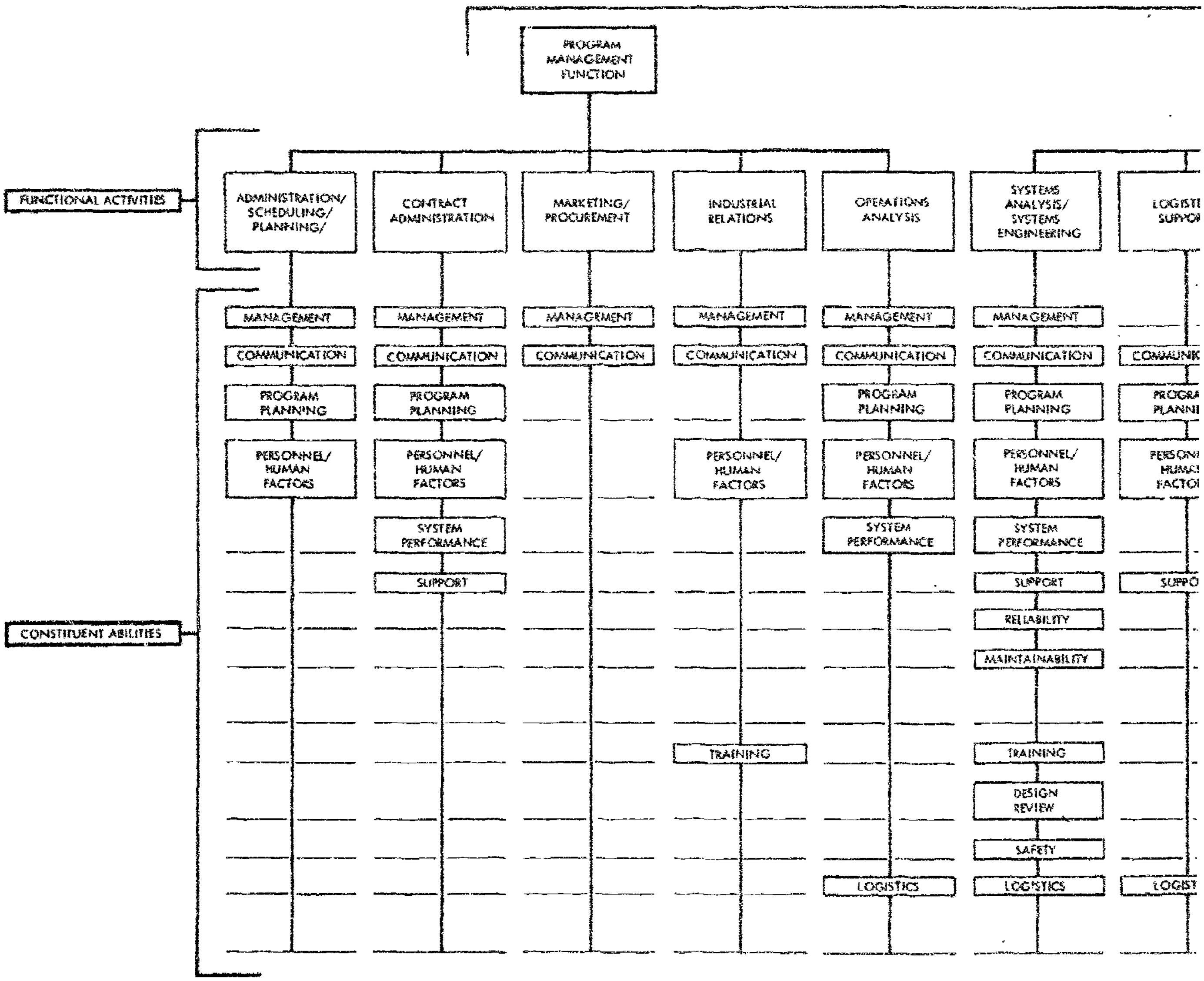
stituent Ability is assigned to various functional activities (e.g., Systems Analysis/Systems Engineering) associated with a system development. During the typical development cycle, these functional activities, initially, are the responsibility of the military agency developing the system. As the system moves out of Phase 1 and Phase 2, the contractor's organization assumes greater responsibility for the accomplisment of required events associated with Systems Effectiveness, with the military organization performing certain concurrent efforts, including monitoring and control activities.

A functional organization chart was developed to illustrate the relationship of the Constituent Abilities to the functional activities responsible for accomplishing the events associated with each Constituent Ability. This chart is shown in Figure 2. Figure 2 illustrates a typical organization comprised of four major organizational functions and eighteen functional activities. The chart is intended to represent a typical organization since it is realized that wide variations exist in the organizational structure of both industrial and military organizations. The responcibility for various functional activities and related Constituent Abilities will vary from exclusively military to both military and industry depending on the nature of a contract and the phase of development (i.e., Phase 1 Military, Phases 2, 3, and 4 Military and Industry). Figure 2 presents the following relationships:

1. All Constituent Abilities appropriate to a specific functional activity are presented below each activity.

2. Constituent Abilities common to more than one functional activity are presented. They can be identified by looking horizontally. If a Constituent Ability is related to more than one functional activity, it will appear beneath each functional activity in the same horizontal row. Therefore, it is only necessary to proceed from left to right on a single line to determine which Constituent Abilities are common to a particular group of functional activities throughout the development cycle.

Based on the analysis of the literature search and user data, the relationships between each Constituent Ability and the Related Events (Subabilities and Related Factors) were developed for each functional activity. The Constituent Abilities are the major dis-


PROGRAM MANAGEMENT FUNCTION
FUNCTIONAL ACTIVITIES
CONSTITUENT ABILITIES
ADMINISTRATION/ SCHEDULING/ PLANNING/
CONTRACT ADMINISTRATION
MARKETING/ PROCUREMENT
INDUSTRIAL RELATIONS
OPERATIONS ANALYSIS
SYSTEMS ANALYSIS/ SYSTEMS ENGINEERING
MANAGEMENT
COMMUNICATION
PROGRAM PLANNING
PERSONNEL/ HUMAN FACTORS
SYSTEM PERFORMANCE
SUPPORT
RELIABILITY
MAINTAINABILITY
TRAINING
DESIGN REVIEW
SAFETY
LOGISTICS

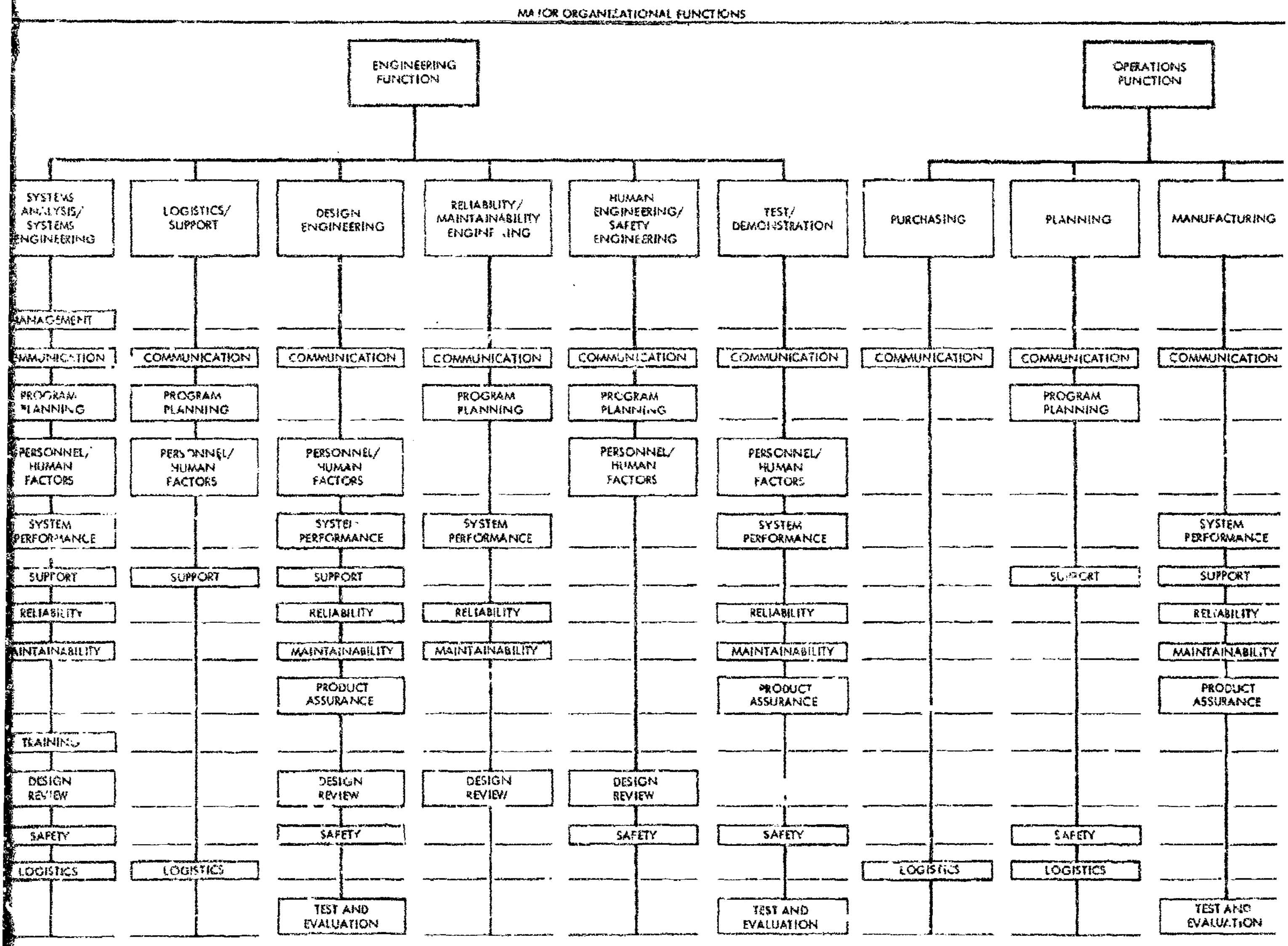


Figure 2. Relationships of

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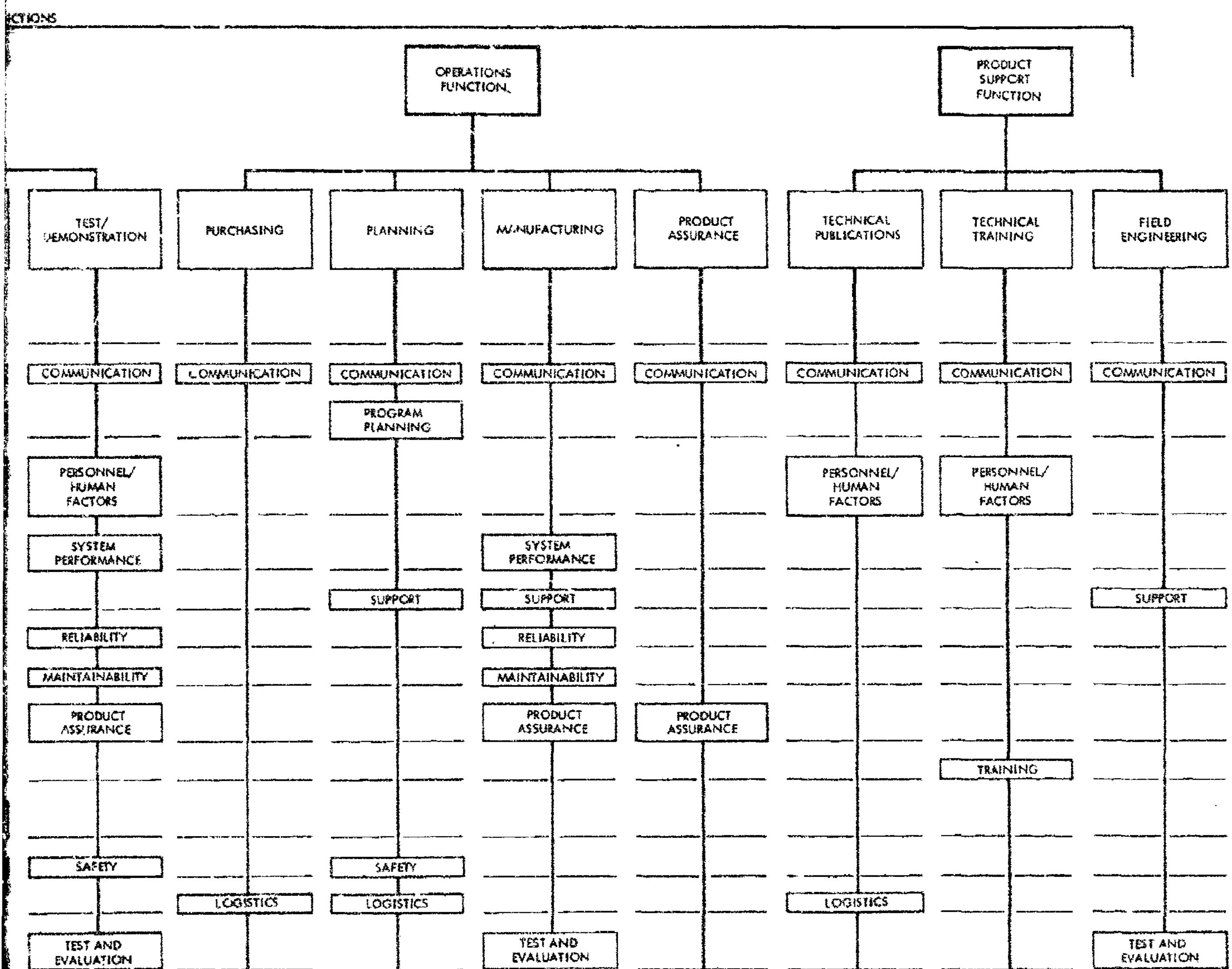


Figure 2. Relationships of Constituent Abilities to a Typical Functional Organization Responsible for System Development

3

ciplines that must be improved to realize an improvement in Systems Effectiveness. The related events describe the type of activity that should take place to improve the Constituent Abilities. The events that comprise each constituent ability that is related to specific functional activities are presented in Appendix III. Information in Appendix III indicates how the events should be applied (descriptor), in what order the events should be applied (priority), and when the events should be applied (phase).

1. Descriptor — key word which describes how an event should be applied. The descriptors used in Appendix III are defined below.

Analyze — to examine in detail, resolve into detailed parts, and draw conclusions.

Assign — to specify or designate.

Coordinate — to bring into harmonious functioning.

Consider — to study carefully with a view to possible acceptance.

Construct — to set in order, to arrange.

Define — to describe and set forth meaning.

Determine — to judge as appropriate and decide conclusively.

Develop — to generate or synthesize and expand in detail.

Document — to write down in order to substantiate and convey information.

Ensure — to make sure or certain.

Establish — to make firm.

Evaluate — to review and ascertain value or amount.

Expedite — to accelerate or facilitate.

Feasibility — quality of being practicable.

Implement — to carry out, put into practice.

Initiate — to start.

Isolate — to separate from all other items.

Maintain — to keep in a specified condition.

Monitor — to check for the purpose of maintaining a standard.

Optimize — to select the best or most favorable alternative.

Perform — to execute an action to meet a specified goal..

Prepare — to make or form.

Provide — to supply for use, to furnish.

Recommend — to offer or suggest favorable representations.

Review — to examine again.

Utilize — to make use of.

2. Priority — priority indicates in what order the events should be applied. Priority is indicated by numerical rank order in each phase of system development, for each Subability and each Related Factor.

3. Phase — phasing indicates when the events should be applied. Phase is indicated by the column in which priority is shown. Thus, a priority (indicated by a number) in the first column on the left in Appendix III, indicates the event should be applied in Phase 1. The phases used in Appendix III are defined below.

Phase 1, Conceptual Phase of Development. Objectives of the conceptual phase are to establish a feasible technical approach for satisfying a given requirement and to evaluate whether the approach is worth pursuing or whether the military requirement should be satisfied in another manner.

Phase 2, Definition Phase of Development. Objectives of the definition phase are to select and define the specific system configuration, to establish performance specifications, to provide cost and schedule estimates, and to confirm the desirability of acquiring the system for use.

Phase 3, Acquisition Phase of Development. Objectives of the acquisition phase are to carry out detailed design and development, conduct category tests, and procure required quantities of hardware.

Phase 4, Operational Phase of Development. Objective of the operational phase is to employ the procured system in an effective manner.

5. CHECK LISTS FOR SYSTEMS EFFECTIVENESS IMPROVEMENT

As a result of the field survey, a number of specific situations were uncovered which have, in fact, resulted in the ineffectiveness of operational systems. These situations were documented and categorized by Constituent Ability and Environment. For example, a factual situation relating to poor accessibility was categorized under the Constituent Ability of maintainability. These situations were then put in check list format so that they might readily be used by system planners and designers to improve Systems Effectiveness. The check lists are presented in Appendix IV.

It should be noted that these check lists are not intended to be all inclusive. They do, however, relate to actual case situations uncovered during the field survey and, therefore, should be used to ensure that these situations are avoided in future systems.

6. HYPOTHETICAL EXAMPLE DEMONSTRATING THE APPLICATION OF THE RESULTS OF THE INVESTIGATION OF ABILITIES

A hypothetical example is presented to illustrate how the relationships of Constituent Abilities to events (Subabilities and Related Factors) can be applied to improve Systems Effectiveness. Included is an explanation of how each figure and table, developed during the study, should be used by system planners and designers.

For this example, assume the objective is to apply the results of the study program to the Engineering Function associated with the development of a major ground electronic system. Also, assume that the primary interest is in the Reliability/Maintainability Functional Activity of the Engineering Function.

Although primary interest is assumed to be the Reliability/Maintainability Activity, all other applicable functions and activities should also be treated in a manner similar to the one described below to ensure that an integrated approach to systems effectiveness is employed throughout system development.

Step 1. First, it is necessary to become familiar with the fourteen Constituent Abilities and the events (Subabilities and Related Factors) related to the Constituent Abilities. The Constituent Abilities and events were shown in Figure 1.

Step 2. After familiarization with all Constituent Abilities and related events, determine which specific Constituent Abilities are related to the functional activity Reliability/Maintainability. A typical organization showing the Engineering Function, the Reliability/Maintainability Activity, and the Constituent Abilities associated with this activity was shown in Figure 2. The Constituent Abilities associated with the functional activity Reliability/Maintainability are: Communication, Program Planning, System Performance, Reliability, Maintainability, and Design Review. The systems effectiveness activity in an organization, with respect to the reliability and maintainability engineering activity, should consider these six Constituent Abilities.

Step 3. To determine the events (Subabilities and Related Factors) that are related to each of the six Constituent Abilities, refer to Appendix III which shows the functional relationships between each Constituent Ability and the events that comprise each Constituent Ability. The Subabilities (directly related to a Constituent Ability) and related factors (indirectly related to a Constituent Ability) are at a level at which they are actually applied in system development to improve Systems Effectiveness. Appendix III also indicates how the events will be used to improve Systems Effectiveness. The order of each event is shown based on the importance of its relationship to each Constituent Ability. The Subabilities and Related Factors are ranked in order of priority or importance. Events are grouped under key word descriptors which serve as a criteria in relation to the depth that each Subability and Related Factor should be treated. The applicable phases of system development in which the events should be applied are also shown in Appendix III.

The use of the information presented in Appendix III as it applies to this example is illustrated as follows:

1. Refer to Appendix III and locate the Engineering Function.

2. Locate the Reliability/Maintainability Functional Activity.

3. Locate the Constituent Ability, Reliability.

4. The Subability, Requirements, is the first Subability to be selected because it ranks first among the Subabilities. (This step indicates priority of application.)

5. Requirements would be analyzed because the key word indicates an analysis is required for this Subability. (This step indicates how the event should be applied.)

6. Requirements would be analyzed in the 1st, 2nd, 3rd, and 4th phases of system development because a numerical priority is shown for each phase. (This step indicates when the event should be applied.)

Step 4. Check lists are presented in Appendix IV to aid in implementing the information presented in Appendix III during system planning and design. Appendix IV provides guidance by indicating which items should be considered or avoided during system design and development. The information presented applies to the engineering function where design and development activities are concentrated.

The identification and listing of all Constituent Abilities, Subabilities, and Related Factors and their relationships presented above provide an organized approach that can be used to optimize Systems Effectiveness. System planners and designers can use this approach to schedule the proper activities, at the proper time, to the required level of effort to improve the effectiveness of systems.

7. DETERMINATION OF INFLUENCES OF ENVIRONMENTS ON SYSTEMS EFFECTIVENESS

Environment has a definite influence on the successful operation of a system. The environment in which a system will be located will determine to a great extent

the ease with which the system can be operated, maintained, and supported. Advance knowledge of environmental problems that a system will experience can be an asset to system planners and designers since it allows them to design controls into the system configuration to contain and retard potential environmental degradation.

The objectives of the study and analysis of environments was to provide system planners and designers with a means of identifying environmental problems and to provide knowledge of environmental conditions and their affect on systems performance that should be design controlled preparatory to final system design and implementation.

Since the word "environment" can be construed to mean many things, environment as discussed herein is defined as those factors which comprise or describe a specific condition or cicumstance under which a system is to be used or located, such as Geographical Location, Climate, or Proximity To Transportation, etc. For the purpose of this study, environment was treated in terms of Environmental Factors and Subfactors. These terms are defined as follows:

An Environmental Factor is a major condition that exists at a location such as, Climate, Temperature, Transportation, or Maintenance Philosophy.

An Environmental Subfactor is a variation that exists in an Environmental Factor. Subfactors for Climate are: Frigid, Tropic, Temperate. Subfactors for Temperature are: High, Low. Subfactors for Transportation are: Acceleration, Shock, Vibration, Packaging.

The Environmental Factors and Subfactors analyzed were those selected by means of research of literature and the field survey as having an influence on overall Systems Effectiveness. The documents researched are included in the References at the end of the report. Texts, specifications, magazines, and individual technical papers dealing

with the subject of environments were used. Data, both narrative and statistical, were obtained from these sources and used in identifying Environmental Factors.

Data obtained from the survey program and follow-up interviews with personnel responsible for the systems surveyed were extremely important. Problems experienced by system users and the diverse environments of their locations presented a cross-section of environmental data that was instrumental in the final selection of Environmental Factors and their effects on Systems Effectiveness.

Environmental Factors studied were not limited to Natural Environments such as Climate, Temperature, and Humidity, but included other factors such as Transportation, Maintenance Philosophy, Storage, and Handling that became evident during the survey program as having a significant affect on Systems Effectiveness. These latter factors are regarded as Man Made Environments as opposed to Natural Environments of Climate, Temperature, Humidity, etc. The Environmental Factors discussed herein are a composite of both Natural and Man Made Environments.

Analysis performed on environmental data revealed that all Environmental Factors emanate from a specific Geographical Location, and each location exhibits climatic parameters within which a system must survive. Terrain and other Natural Environmental Factors, such as Precipitation, Wind Velocity, etc., are all traceable to Geographical Location. These are the factors with which man can do little except adapt to within limits of his ingenuity. They must be compensated for by sound system planning and design.

Man Made Environments and related Environmental Factors, however, are more controllable. Man can adapt to problems of Transportation, Proximity to Supplies, Poor Roads, and Space Restrictions if he is made fully aware of the problems that stem from the existence of these Environmental Factors. Therefore, in the area of Man Made Environ-

ment, man has the option of improving existing conditions in the system location by determining potential problems and utilizing his knowledge of these problems to ensure that they are eliminated or minimized prior to installation and operation of the system. Such action is necessary to optimize Systems Effectiveness.

The investigation of environments was divided into four major tasks. The first task concerned identification of all Environmental Factors constituting an environment which have an influence on the effectiveness of ground electronic systems. The second was the determination of Subfactors that exist within each Environmental Factor identified. The third task was related to the identification of Pertinent Environmental Factors and Subfactors which proved to have a significant or critical influence on Systems Effectiveness. The fourth task involved relating the Effects of Pertinent Environmental Factors and Subfactors to Systems Effectiveness, Systems Performance, and Performance Characteristics.

a. Identification of Environmental Factors

Research of literature and analysis of data collected during the survey program revealed that there were many Environmental Factors that could be considered in their relation to ground electronic systems. Analysis of these Environmental Factors was performed to ascertain the degree of degradation each presented in regard to System Performance and Performance Characteristics. Only those factors found to have a direct influence on System Performance were tabulated in the final analysis of these data. The remaining Environmental Factors were considered to have no affect or were not applicable to ground electronic systems and therefore, not considered appropriate to the needs of this study. This analysis resulted in the identification of 43 Environmental Factors that were found to influence Systems Effectiveness. These factors are shown in Figure 3.

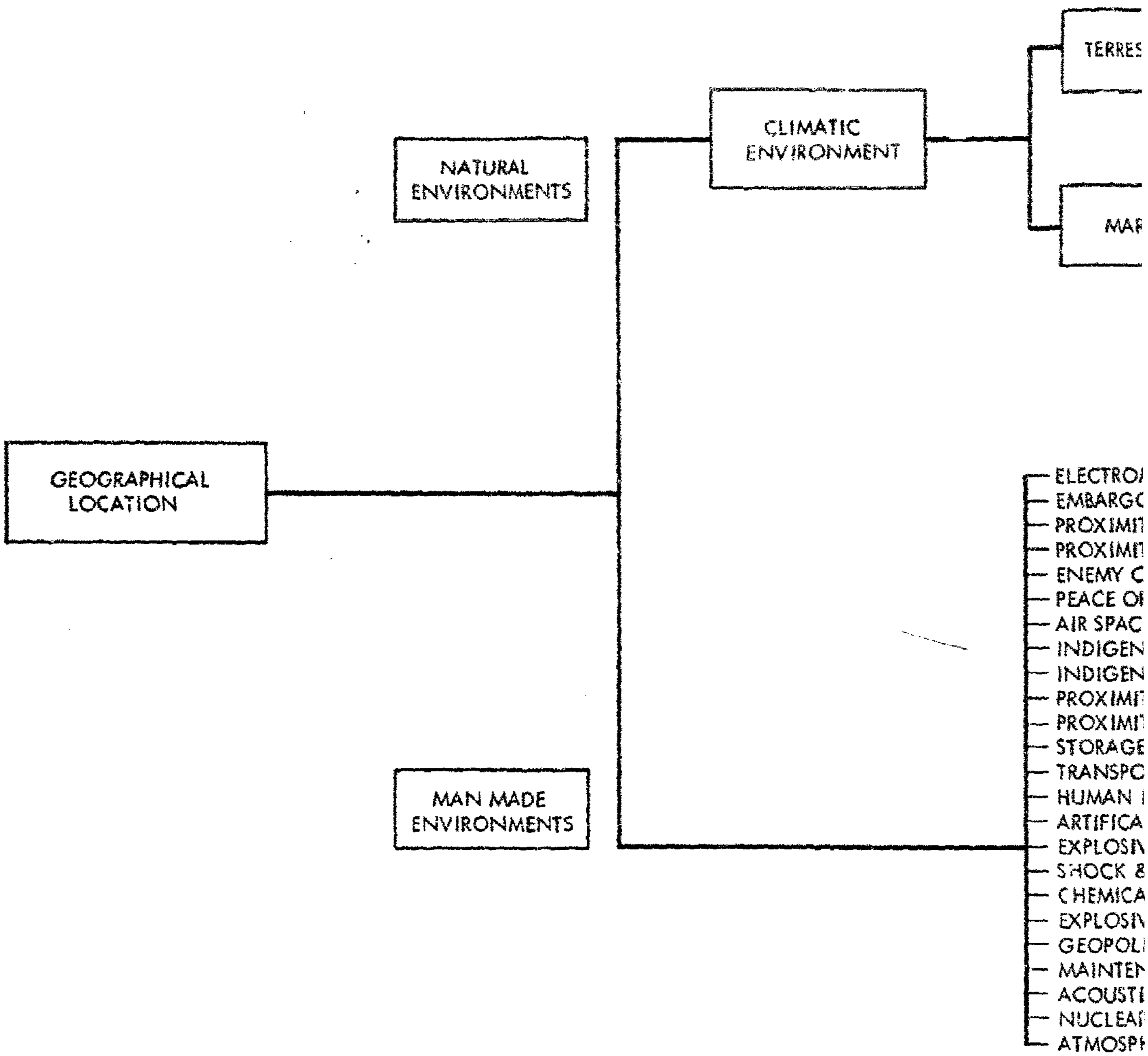


Figure 3. Environmental Factors

TERRESTRIAL ENVIRONMENT

MARINE ENVIRONMENT

- TEMPERATURE
- HUMIDITY
- PRESSURE
- SAND & DUST
- SALT FOG/SPRAY
- WIND
- PRECIPITATION
- GEOMAGNETISM
- ELECTROMAGNETIC INTERFERENCE
- IONIZED GASES
- GRAVITY
- INSECTS
- OZONE
- WAVES
- OCEAN CURRENTS

- ELECTROMAGNETIC INTERFERENCE
- EMBARGO/BLOCKADE
- PROXIMITY TO HOSTILE & UNFRIENDLY AREAS
- PROXIMITY TO POPULATED AREAS
- ENEMY COUNTERMEASURES
- PEACE OR WAR CONDITIONS
- AIR SPACE RESTRICTIONS
- INDIGENOUS SUPPORT PERSONNEL
- INDIGENOUS TECHNICAL PERSONNEL
- PROXIMITY TO SUPPORT & STORAGE FACILITIES
- PROXIMITY TO TRANSPORTATION
- STORAGE ENVIRONMENT
- TRANSPORTATION
- HUMAN ENVIRONMENT
- ARTIFICAL ENVIRONMENT
- EXPLOSIVE ATMOSPHERE
- SHOCK & VIBRATION
- CHEMICAL REACTION
- EXPLOSIVE DECOMPRESSION
- GEOPOLITICS
- MAINTENANCE PHILOSOPHY
- ACOUSTICS
- NUCLEAR RADIATION
- ATMOSPHERIC POLLUTION

Figure 3 illustrates that the basic root for considering any of these environments is the Geographical Location in which a system may be installed. There are two paths that emanate from Geographical Location: Natural Environments and Man Made Environments. When following the path of Natural Environments, such as, Temperature, Humidity, etc., the path moves through Climatic Environment, which is directly traceable to Geographical Location. Next is the branch between Terrestrial (land) and Marine (water) Environments. Marine Environment is shown for ground electronic equipment because research indicated that conventional ground electronic equipment was also used in facilities such as Texas Towers and platforms in the ocean off coastal waters. This type of equipment is also located on similar platforms in lakes and rivers.

Continuing the path from the branch of both Terrestrial and Marine Environment, the next group of Environmental Factors concern all those factors which were related to both land and sea, traceable back through Climate to Geographical Location.

When tracing the route of environments from Geographical Location through Man Made Environments, it is not necessary to progress through Climatic Environment. As stated previously, Man Made Environments are induced, therefore, climate plays a lesser role in its effect on these environments in relation to Systems Effectiveness. The path, therefore, goes directly from Geographical Location to Man Made Environmental Factors. It should be noted that the Man Made Environments illustrated in Figure 3 represent specifically those environments which man creates himself and can regulate or control.

The most important Environmental Factor identified was Geographical Location. To better understand the importance of Geographical Location, a map of the world is presented in Figure 4. This map is coded to indicate the main environmental divisions of the world. Codes and their meaning are as follows:

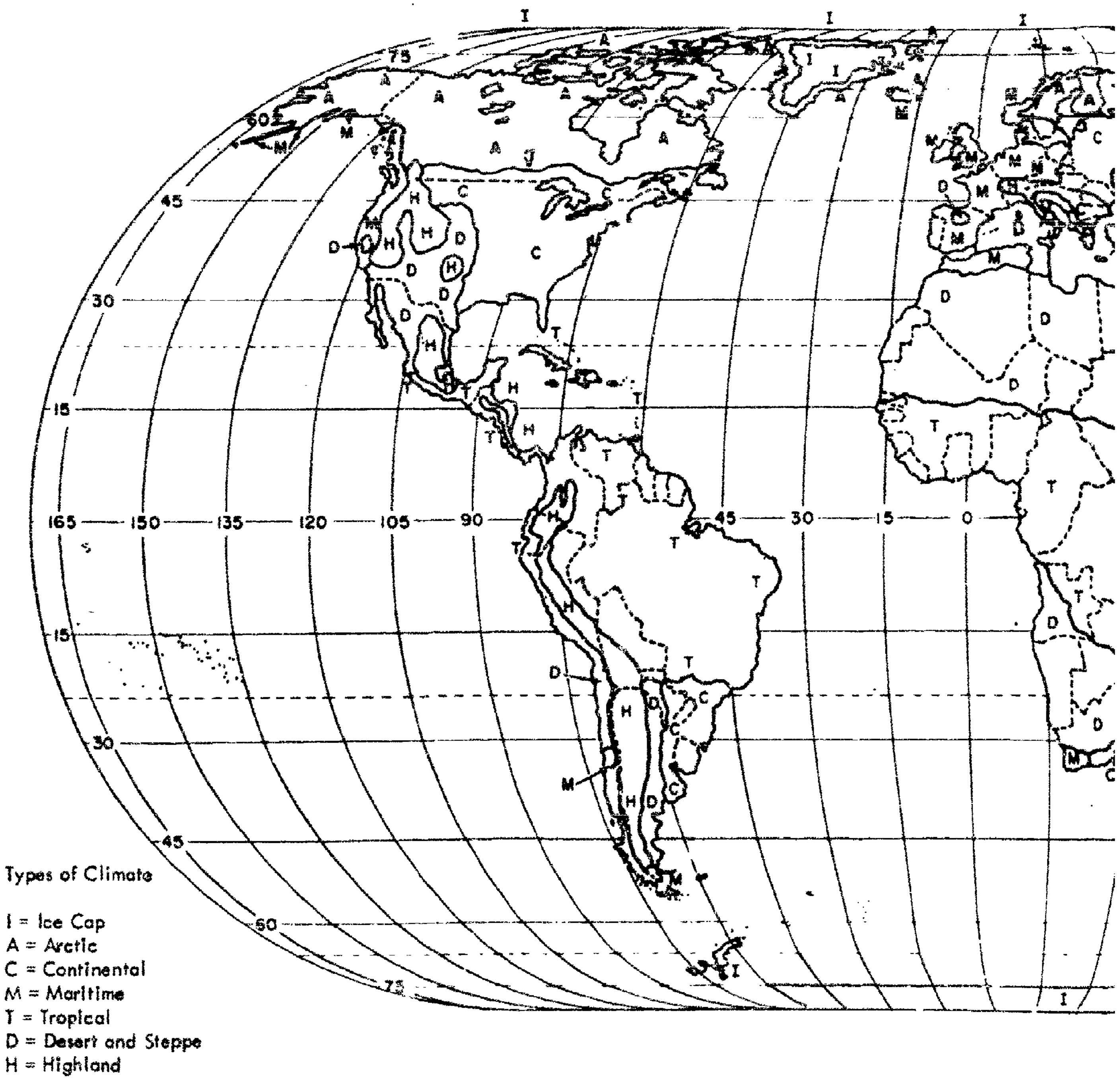


Figure 4. Climatic Classifications of the Earth


75
60
45
30
15
45
60
75
90
105
135
150
165
180
15
30
45
60
75

I	=	Ice Cap
A	=	Arctic
M	=	Maritime
C	=	Continental
D	=	Desert and Steppe
T	=	Tropical
H	=	Highland

The following descriptive infomation is presented in order to more clearly identify these seven divisions.

The Ice Cap region (I) includes the poles, polar islands, and most of Greenland (except coastal regions). The prevalent climatic condition in this region is extremely cold temperature. Warmest temperatures for this area are well below freezing. High winds and blowing snow are also prevalent in this region.

The Arctic region (A) includes Alaska, Northern Canada, the coast of Greenland, most of Iceland, most of the Scandinavian countries and the area east of Leningrad bounded by Lake Baikal, the Sea of Okhotsk, and the Kamchatka Peninsula. Prevalent environmental conditions in this area include extremely low temperatures, blowing snow, and high winds in the cold seasons.

The Muritime region (M) includes the West Coast of North America from Juneau south to Humboldt Bay in Northern California; coastal sections of California from San Francisco to San Diego; the coastline of Chile from Tacopilla south, including Cape Horn and the Falklands; the southern third of Ireland; the British Isles; the west coast of Norway; Southern Norway and Sweden; the region surrounded by Gottland (in the Baltic), Danzig, Cracow, Breslau, Leipzig, the Alps, and the Rhone Valley; the Mediterranean coast line; the Black Sea coastline of Northern Turkey and Southern Crimea; the area around Capetown in South Africa; the Australian coastline from Perth to the Esperance area and from the Eyre Peninsula to Gippsland; and Tasmania and New Zealand. Environmental conditions prevalent in this region are humidity, sunshine, salt spray, extreme temperatures, and fungus.

The Continental region (C) includes the continental United States and Southern Canada from the Rockies to the Atlantic; the Buenos Aires area in South America; the Southeast tip of Africa; the greater part of the Balkans, Eastern Poland, Northern Ukraine, and a narrow strip extending East almost to Lake Baikal; Southeast Siberia; and Eastern China. Environmental conditions of importance in this region are temperature extremes, humidity, sand and dust, and driven snow.

The Desert and Steppe region (D) includes most of the Western United States and Lower California (Mexico); Patagonia in South America; the Sahara region and Southwest Africa; the Arabian Peninsula; the Persian Gulf area; Anatolia; the Southern Ukraine; Dzungaria, Sinkiang; Mongolia; and most of Australia. Environmental conditions of importance in this region are temperature extremes, humidity, sand and dust, sunshine, and driven snow.

The Tropical region (T) includes parts of Mexico; the Southern tip of Florida; the West Indies; most of Central America; all of South America North of the Tropic of Capricorn except the Andes Mountains and the central west coast; all of Africa from 10° North Latitude southward to approximately 8° South Latitude on the west coast and diagnonally southeast to 25° South Latitude on the east coast, except two upland areas; most of India and Pakistan; Southeastern Asia; the Malay Archipelago; the northern coast of Australia; the East Indies; and other South Pacific islands. Principal environmental conditions in this region are extremely high temperatures, humidity, rain, salt spray, fungus, sand and dust.

The Highland region (H) includes the Rocky Mountains and the Sierra Nevada range of the Western United States; mountainous areas of Mexico and Central America; the Andes Mountains in South America; the European Alps; the

mountains of Ethopia; the Caucasian Mountains; and the Tibetan Plateau. The most important environmental conditions in this region are pressures which are comparatively lower than sea level, extreme temperatures, snow, and winds.

b. Identification of Environmental Subfactors

Once the Environmental Factors were identified, it became necessary to further analyze environments to better understand their affect on Systems Effectiveness. It was determined during the process of this analysis that in each case, an environmental factor was comprised of many Subfactors (environmental variations, e.g., Temperature, High and Low) which, in turn, could present a separate and distinct set of problems in relation to Systems Effectiveness.

Research of literature and analysis of data obtained from the survey program resulted in the development of a list of Environmental Subfactors for each of the 43 Environmental Factors. For example, in the area of Climate, it was determined that there were three Subfactors, Frigid, Tropic, and Temperate. As in the investigation of Environmental Factors, it was also determined that there were many possible Subfactors that could be identified, however, not all of them had a direct influence on Systems Effectiveness. The criteria for final selection of Subfactors were based on the significance of their influence on Systems Effectiveness. The result of the analysis was the development of a listing of relevant Subfactors for each of the 43 Environmental Factors. This listing is shown in Table 1.

c. Selection of Pertinent Environmental Factors and Subfactors

The first two tasks described above resulted in the identification of 43 Environmental Factors and related Subfactors which were found to have some degree of influence on the effectiveness of ground electronic systems. The relative degree of this

TABLE 1
ENVIRONMENTAL FACTORS AND SUBFACTORS

GEOGRAPHICAL LOCATION
- Ice Cap
- Arctic
- Maritime
- Continental
- Desert & Steppe
- Tropical
- Highland

NATURAL ENVIRONMENTS

- Climatic Environment
  - Frigid
  - Tropic
  - Temperate
- Marine Environment
  - Deep Sea
  - Off Shore
  - Rivers & Lakes
- Terrestrial Environment
  - Mountains
  - Low Hills
  - Valleys
  - Flatlands
  - Coastal
- Temperature
  - Ambient Low
  - Ambient High
- Humidity
  - Ambient Low
  - Ambient High
- Pressure
  - Ambient Low
  - Ambient High
- Sand & Dust
  - Fine Particles
  - Coarse Particles
- Salt, Fog & Spray
  - Degree of Concentration
- Wind
  - 40 MPH to 100 MPH
  - 100 MPH & Over
- Precipitation
  - Rain
  - Snow
  - Ice
- Geomagnetism
  - Magnetization (Lines of Force)

MAN MADE ENVIRONMENTS

- Electromagnetic Interference
  - Generators
  - Vehicles
  - Proximity of Equipment to Each Other
  - Aircraft
- Embargo/Blockade
  - Transportation
  - Health Hazards
- Proximity to Hostile or Unfriendly Areas
  - Jamming
  - Spying
  - Sabotage
  - Harrassment
- Proximity to Populated Areas
  - Radiation
  - Interference (Electronic)
  - Security
- Enemy Countermeasures
  - Jamming
  - Sabotage
- Peace or War Conditions
  - Security
  - Priority
- Air Space Restrictions
  - Site Access (Location)
  - Security
- Indigenous Support Personnel
  - Language
  - Inter-Government Relations
  - Security
- Indigenous Technical Personnel
  - Language
  - Engineering Techniques
  - Inter-Government Relations
  - Security
- Proximity to Support & Storage Facilities
  - Remote Areas
  - Space Considerations & Restrictions
  - Vehicle Availability

TABLE 1. Continued. (Sheet 2 of 3)

NATURAL ENVIRONMENTS	MAN MADE ENVIRONMENTS
Electromagnetic Interference	Proximity to Transportation
Aurora	Remote Areas
Static Electricity	Vehicle Availability
Lightning	Road Conditions
Cosmic Radiation	Storage Environment
Solar Radiation	Temperature (Control)
Micrometeorites	Humidity (Control)
Cosmic Dust	Fungus (Control)
Ionized Gases	Precipitation (Control)
Degree of Ionization	Sunshine (Control)
(Relation to Altitude)	Sand & Dust (Control)
Gravity	Transportation
Degree of Gravity	Acceleration
Insects	Shock
Surface	Vibration
Subterrainean	Packaging
Ozone	Handling
Degree of Concentration	Temperature (Control)
Waves	Humidity (Control)
Height	Precipitation (Control)
Swell	Sand & Dust (Control)
Wind Forces	Salt Spray (Control)
Ocean Currents	Commercial Modes
Surface	Military Modes
Underwater	Human Environment
Warm	Heat
Cold	Cold
	Noise
	Light
	Safety
	Artificial Environment
	Air Conditioning
	Heating
	Ventillation
	Shock & Vibration
	Acoustical
	Thermal
	Sonic
	Chemical Reaction
	Dissimilar Metals
	Electrolysis
	Contamination
	Explosive Decompression
	Loss of Pressure
	Geo-Politics
	Inter-Government Relations

TABLE 1. Continued. (Sheet 3 of 3)

NATURAL ENVIRONMENTS	MAN MADE ENVIRONMENTS
	Maintenance Philosophy
	Throw-away at Failure Plan
	Repair at Failure Plan
	Return at Failure Plan
	Acoustics
	Noise
	Harmonics
	Nuclear Radiation
	Equipment Protection
	Human Safety
	Atmospheric Pollution
	Smoke
	Gases
	Nuclear Contaminents
	Explosive Atmosphere
	Combustible Gases

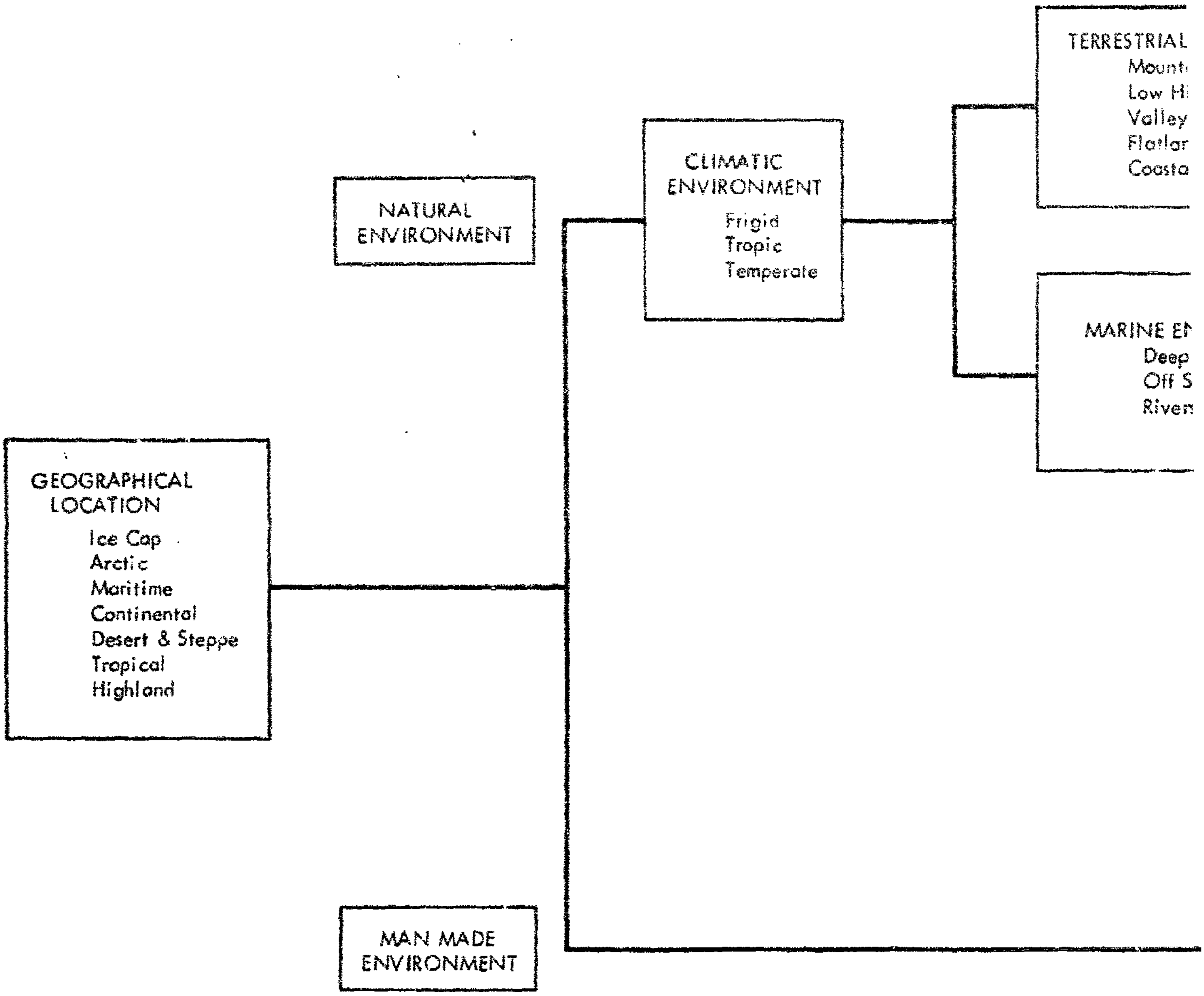
influence was found to vary from minimal to critical. In order to provide systems planners and designers with the most pertinent information, each Factor and related Subfactor was analyzed and organized into three categories, minimal, significant, and critical, depending on the degree of influence on Systems Effectiveness. The degree of influence on Systems Effectiveness was determined from analysis of information obtained during the field survey, the research of literature and, applicable operational experience data.

A total of 17 Environmental Factors and their related Subfactors were determined to be significant or critical. These Factors and related Subfactors are shown in Figure 5.

d. Relationships of Pertinent Environmental Factors and Subfactors

Because of the interacting nature of Environmental Factors and Subfactors upon each other and because many Environmental Factors can occur simultaneously, a problem in illustrating all possible combinations of Environmental Factors to each other became evident. Further, to present all these possible combinations would be of limited value since many of the combinations could include those that may never actually occur. Therefore, it was decided to present only practical combinations of environmental relationships. The matrix shown in Figure 6 was developed for this purpose.

The matrix is an echelon type that illustrates practical combinations of Pertinent Environmental Factors and Subfactors and their relationships to each other. The matrix provides systems planners and designers with the information they must be made aware of when considering system design parameters, which in this instance includes not only the equipment configuration, but its eventual location, climatic conditions, available means of transportation, etc.


NATURAL ENVIRONMENT
CLIMATIC ENVIRONMENT
Frigid
Tropic
Temperate
TERRESTRIAL
Valley
MARINE
Deep
GEOGRAPHICAL LOCATION
Ice Cap
Arctic
Maritime
Continental
Desert & Steppe
Tropical
Highland
MAN MADE ENVIRONMENT

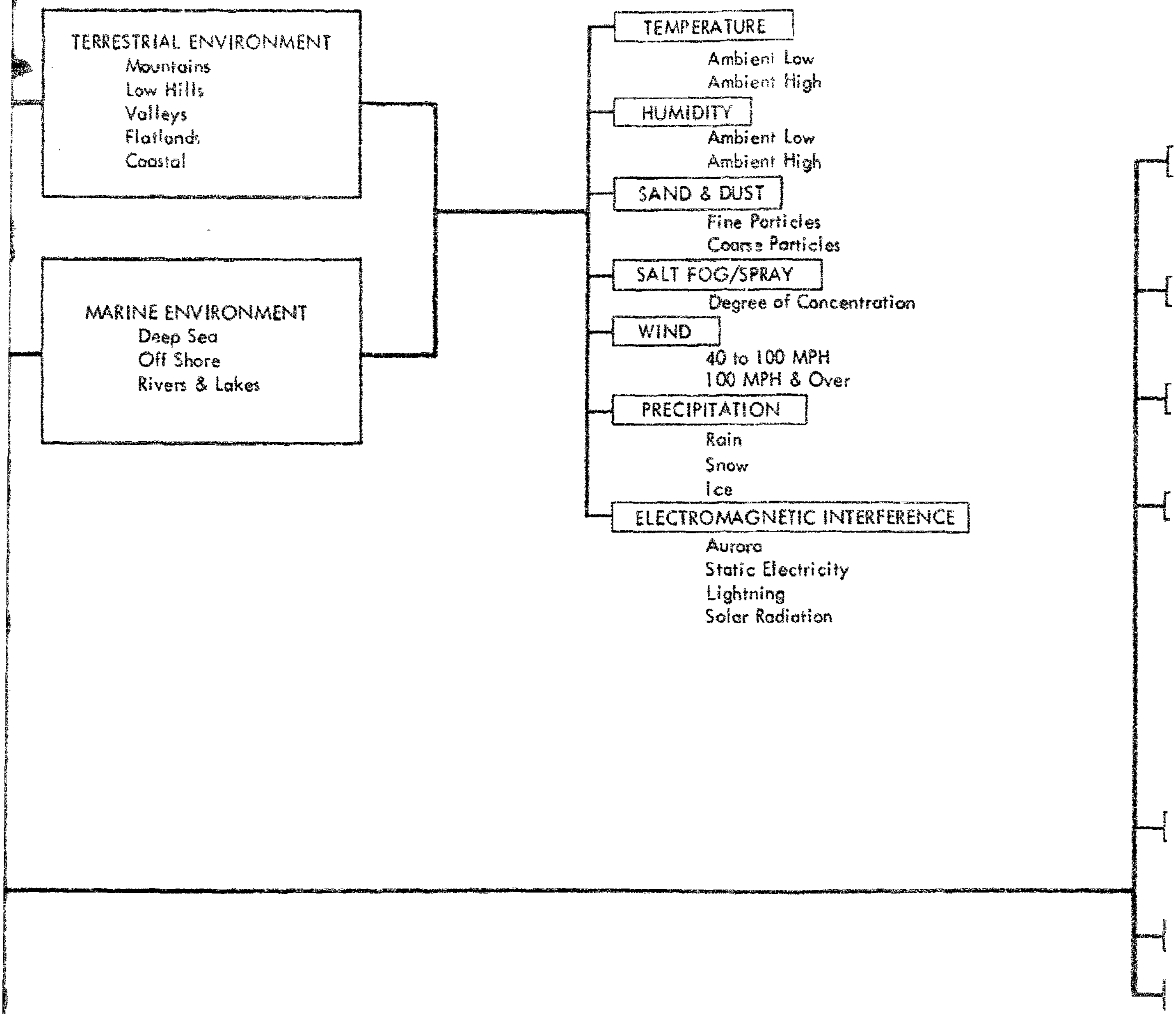

TERRESTRIAL ENVIRONMENT
Mountains
Low Hills
Valleys
Flatlands
Coastal
MARINE ENVIRONMENT
Deep Sea
Off Shore
Rivers & Lakes
TEMPERATURE
Ambient Low
Ambient High
HUMIDITY
Ambient Low
Ambient High
SAND & DUST
Fine Particles
Coarse Particles
SALT FOG/SPRAY
Degree of Concentration
WIND
40 to 100 MPH
100 MPH & Over
PRECIPITATION
Rain
Snow
Ice
ELECTROMAGNETIC INTERFERENCE
Aurora
Static Electricity
Lightning
Solar Radiation

Figure 5. Pe

2

- RATURE
  - Ambient Low
  - Ambient High
- ITY
  - Ambient Low
  - Ambient High
- & DUST
  - Fine Particles
  - Coarse Particles
- OG/SPRAY
  - Degree of Concentration
-
  - 40 to 100 MPH
  - 100 MPH & Over
- ITATION
  - Rain
  - Snow
  - Ice
- OMAGNETIC INTERFERENCE
  - Aurora
  - Static Electricity
  - Lightning
  - Solar Radiation

- ELECTROMAGNETIC INTERFERENCE
  - Generators
  - Vehicles Ignition
  - Proximity of Equip. to Each Other
  - Aircraft
- PROXIMITY TO SUPPORT & STORAGE FACILITIES
  - Remote Areas
  - Space Considerations & Restrictions
  - Vehicle Availability
- PROXIMITY TO TRANSPORTATION
  - Remote Areas
  - Vehicle Availability
  - Road Conditions
- TRANSPORTATION
  - Acceleration
  - Shock
  - Vibration
  - Packaging
  - Handling
  - Temperature (Control)
  - Humidity (Control)
  - Precipitation (Control)
  - Sand & Dust (Control)
  - Salt Spray (Control)
  - Commercial Modes
  - Military Modes
- ARTIFICIAL ENVIRONMENT
  - Air Conditioning
  - Heating
  - Ventillation
- CHEMICAL REACTION
  - Dissimilar Metals
- MAINTENANCE PHILOSOPHY
  - Throw Away At Failure Plan
  - Repair At Failure Plan
  - Return At Failure Plan

Figure 5. Pertinent Environmental Factors and Subfactors

PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	GEOGRAPHICAL LOCATION	Ice Cap	Arctic	Maritime	Continental	Desert & Steppe	Tropical	Highland	CLIMATIC ENVIRONMENT	Frigid	Tropic	Temperate	TERRESTRIAL ENVIRONMENT	Mountains	Low Hills	Valleys	Flatlands	Coastal	MARINE ENVIRONMENT	Deep Sea	Off Shore	Rivers & Lakes	TEMPERATURE	Ambient Low	Ambient High	HUMIDITY	Ambient Low
GEOGRAPHICAL LOCATION																											
Ice Cap		■																									
Arctic			■																								
Maritime				■																							
Continental					■																						
Desert & Steppe						■																					
Tropical							■																				
Highland								■																			
CLIMATIC ENVIRONMENT																											
Frigid		●	●	●	●			●		■																	
Tropic				●		●	●				■																
Temperate				●	●	●		●				■															
TERRESTRIAL ENVIRONMENT																											
Mountains		●	●	●	●	●	●	●		●	●	●		■													
Low Hills		●	●	●	●	●	●			●	●	●			■												
Valleys		●	●	●	●	●	●			●	●	●				■											
Flatlands		●	●	●	●	●	●			●	●	●					■										
Coastal		●	●	●	●	●	●			●	●	●						■									
MARINE ENVIRONMENT																											
Deep Sea			●							●	●	●								■							
Off Shore			●	●						●	●	●									■						
Rivers & Lakes			●	●	●		●	●		●	●	●										■					

Ambient Low	Ambient High	HUMIDITY	Ambient Low	Ambient High	SAND & DUST	Fine Particles	Coarse Particles	WIND	40 to 100 MPH & Over	PRECIPITATION	Rain	Snow	Ice	ELECTROMAGNETIC INTERFERENCE (NATURAL)	Aurora	Static Electricity	Lightning	Solar Radiation	ELECTROMAGNETIC INTERFERENCE (MAN MADE)	Generators	Vehicle Ignition	Prox. of Equip. to Each Other	Aircraft	PROXIMITY TO SUPPORT & STORAGE FACILITIES	Remote Areas	Space Consid'ns / Restric'ns	Vehicle Availability	PROXIMITY TO TRANSPORTATION	Remote Areas	Vehicle Availability	Road Conditions	TRANSPORTATION	Acceleration	Shock	Vibration	Packaging

Figure 6. Relationships of Per

2

Solar Radiation	ELECTROMAGNETIC INTERFERENCE (MAN MADE)	Generators	Vehicle Ignition	Prox. of Equip. to Each Other	Aircraft	PROXIMITY TO SUPPORT & STORAGE FACILITIES	Remote Areas	Space Consid'ns / Restric'ns	Vehicle Availability	PROXIMITY TO TRANSPORTATION	Remote Areas	Vehicle Availability	Road Conditions	TRANSPORTATION	Acceleration	Shock	Vibration	Packaging	Handling	Temperature (Control)	Humidity (Control)	Precipitation (Control)	Sand & Dust (Control)	Salt Spray (Control)	Commercial Modes	Military Modes	ARTIFICIAL ENVIRONMENT	Air Conditioning	Heating	Ventilating	CHEMICAL REACTION	Dissimilar Metals	MAINT. PHILOSOPHY	Throw Away At Failure Plan	Repair At Failure Plan	Return At Failure Plan

Figure 6. Relationships of Pertinent Environmental Factors and Subfactors to Each Other

PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	GEOGRAPHICAL LOCATION	Ice Cap	Arctic	Maritime	Continental	Desert & Steppe	Tropical	Highland	CLIMATIC ENVIRONMENT	Frigid	Tropic	Temperate	TERRESTRIAL ENVIRONMENT	Mountains	Low Hills	Valleys	Flatlands	Coastal	MARINE ENVIRONMENT	Deep Sea	Off Shore	Rivers & Lakes	TEMPERATURE	Ambient Low	Ambient High	HUMIDITY	Ambient Low	Ambient High
TEMPERATURE																												
Ambient Low		●	●	●	●			●		●		●		●	●	●	●	●		●	●	●		■				
Ambient High				●	●	●	●				●	●		●	●	●	●	●		●	●	●			■			
HUMIDITY																												
Ambient Low		●	●	●	●	●		●		●		●		●	●	●	●	●						●	●		■	
Ambient High				●	●		●	●			●	●		●	●	●	●	●		●	●	●		●	●			■
SAND & DUST																												
Fine Particles				●	●	●	●	●			●	●		●	●	●	●	●						●	●			
Coarse Particles				●	●	●	●	●			●	●		●	●	●	●	●						●	●			
WIND																												
40 to 100 MPH & Over		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
PRECIPITATION																												
Rain				●	●		●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Snow		●	●	●	●	●		●		●		●		●	●	●	●	●		●	●	●		●				●
Ice		●	●	●	●			●		●		●		●	●	●	●	●			●	●		●			●	●
ELECTROMAGNETIC INTERFERENCE (NATURAL)																												
Aurora		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Static Electricity		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Lightning			●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Solar Radiation		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●

Ambient Low	●	●	●	●		●		●		●						■				
Ambient High	●	●	●	●		●	◐	●		●					■					
SAND & DUST																				
Fine Particles						●	◐	●		●			■							
Coarse Particles										●		■								
WIND																				
40 to 100 MPH & Over	●	●	●	●		●	●	●		■										
PRECIPITATION																				
Rain		●	●					■												
Snow							■													
Ice						■														
ELECTROMAGNETIC INTERFERENCE (NATURAL)																				
Aurora				■																
Static Electricity	●	●	■																	
Lightning		■																		
Solar Radiation	■																			
ELECTROMAGNETIC INTERFERENCE (MAN MADE)																				
Generators																				
Vehicle Ignition																				
Prox. of Equip. to Each Other																				
Aircraft																				
PROXIMITY TO SUPPORT & STORAGE FACILITIES																				
Remote Areas																				
Space Consid'ns / Restric'ns																				
Vehicle Availability																				
PROXIMITY TO TRANSPORTATION																				
Remote Areas																				
Vehicle Availability																				
Road Conditions																				
TRANSPORTATION																				
Acceleration																				
Shock																				
Vibration																				
Packaging																				
Handling																				
Temperature (Control)																				
Humidity (Control)																				
Precipitation (Control)																				

2

Vehicle Ignition	Prox. of Equip. to Each Other	Aircraft	PROXIMITY TO SUPPORT & STORAGE FACILITIES	Remote Areas	Space Consid'ns / Restric'ns	Vehicle Availability	PROXIMITY TO TRANSPORTATION	Remote Areas	Vehic. Availability	Road Conditions	TRANSPORTATION	Acceleration	Shock	Vibration	Packaging	Handling	Temperature (Control)	Humidity (Control)	Precipitation (Control)	Sand & Dust (Control)	Salt Spray (Control)	Commercial Modes	Military Modes	ARTIFICIAL ENVIRONMENT	Air Conditioning	Heating	Ventilating	CHEMICAL REACTION	Dissimilar Metals	MAINT. PHILOSOPHY	Throw Away At Failure Plan	Repair At Failure Plan	Return At Failure Plan

Figure 6. Continued

3

PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	GEOGRAPHICAL LOCATION	Ice Cap	Arctic	Maritime	Continental	Desert & Steppe	Tropical	Highland	CLIMATIC ENVIRONMENT	Frigid	Tropic	Temperate	TERRESTRIAL ENVIRONMENT	Mountains	Low Hills	Valleys	Flatlands	Coastal	MARINE ENVIRONMENT	Deep Sea	Off Shore	Rivers & Lakes	TEMPERATURE	Ambient Low	Ambient High	HUMIDITY	Ambient Low	Ambient High
ELECTROMAGNETIC INTERFERENCE (MAN MADE)																												
Generators		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Vehicle Ignition		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●										●
Prox. of Equip. to Each Other		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						●
Aircraft		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
PROXIMITY TO SUPPORT & STORAGE FACILITIES																												
Remote Areas		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●				
Space Consid'ns / Restric'ns		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●			●	●						
Vehicle Availability		●	●	●	●	●	●	●		●	●	●		●	●									●				
PROXIMITY TO TRANSPORTATION																												
Remote Areas		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●				
Vehicle Availability		●	●	●	●	●	●	●		●	●	●		●	●	●												
Road Conditions		●	●	●	●	●	●	●		●	●	●		●	●	●												

2

													TEMPERATURE
		●		●		●							Ambient Low
													Ambient High
													HUMIDITY
													Ambient Low
									●	●			Ambient High
													SAND & DUST
													Fine Particles
													Coarse Particles
													WIND
		●		●									40 to 100 MPH & Over
													PRECIPITATION
●		●		●		●							Rain
●		●		●		●							Snow
●		●		●		●							Ice
													ELECTROMAGNETIC INTERFERENCE (NATURAL)
													Aurora
													Static Electricity
													Lightning
													Solar Radiation
													ELECTROMAGNETIC INTERFERENCE (MAN MADE)
					●						■		Generators
					●				●	■			Vehicle Ignition
					●				■				Prox. of Equip to Each Other
					●			■					Aircraft
													PROXIMITY TO SUPPORT & STORAGE FACILITIES
●	●			●	●	■							Remote Areas
●	●	●			■								Space Consid'ns / Restric'ns
●				■									Vehicle Availability
													PROXIMITY TO TRANSPORTATION
		■											Remote Areas
	■												Vehicle Availability
■													Road Conditions
													TRANSPORTATION
													Acceleration
													Shock
													Vibration

Solar Radiation	ELECTROMAGNETIC INTERFERENCE (MAN MADE)	Generators	Vehicle Ignition	Prox. of Equip. to Each Other	Aircraft	PROXIMITY TO SUPPORT & STORAGE FACILITIES	Remote Areas	Space Consid'ns / Restric'ns	Vehicle Availability	PROXIMITY TO TRANSPORTATION	Remote Areas	Vehicle Availability	Road Conditions	TRANSPORTATION	Acceleration	Shock	Vibration	Packaging	Handling	Temperature (Control)	Humidity (Control)	Precipitation (Control)	Sand & Dust (Control)	Salt Spray (Control)	Commercial Modes	Military Modes	ARTIFICIAL ENVIRONMENT	Air Conditioning	Heating	Ventilating	CHEMICAL REACTION	Dissimilar Metals	MAINT. PHILOSOPHY	Throw Away At Failure Plan	Repair At Failure Plan	Return At Failure Plan
		■																																		
			■																																	
			●	■																																
					■																															
							■																													
		●	●	●	●		●	■																												
							●		■																											
								●			■																									
							●	●				■																								
							●	●	●				■																							

Figure 6. Continued

3

PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	GEOGRAPHICAL LOCATION	Ice Cap	Arctic	Maritime	Continental	Desert & Steppe	Tropical	Highland	CLIMATIC ENVIRONMENT	Frigid	Tropic	Temperate	TERRESTRIAL ENVIRONMENT	Mountains	Low Hills	Valleys	Flatlands	Coastal	MARINE ENVIRONMENT	Deep Sea	Off Shore	Rivers & Lakes	TEMPERATURE	Ambient Low	Ambient High	HUMIDITY	Ambient Low	
TRANSPORTATION																												
Acceleration		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Shock		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Vibration		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Packaging		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Handling		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Temperature (Control)		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Humidity (Control)				●	●		●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Precipitation (Control)		●	●	●	●		●	●		●	●	●		●	●	●	●	●		●	●	●		●	●		●	●
Sand & Dust (Control)				●	●	●	●	●			●	●					●	●										
Salt Spray (Control)		●	●	●	●		●			●	●	●						●		●	●			●	●		●	●
Commercial Modes		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Military Modes		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
ARTIFICIAL ENVIRONMENT																												
Air Conditioning				●	●	●	●	●			●	●		●	●	●	●	●		●	●	●			●			●
Heating		●	●	●	●	●	●	●		●		●		●	●	●	●	●		●	●	●		●				●
Ventilating		●	●	●	●	●		●		●	●	●		●	●	●	●	●		●	●	●			●		●	●
CHEMICAL REACTION																												
Dissimilar Metals		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●			●			●
MAINT. PHILOSOPHY																												
Throw Away At Failure Plan		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Repair At Failure Plan		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						
Return At Failure Plan		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●						

				●		●		●				●		●	●	●							Ambient High
																							HUMIDITY
						●						●		●	●	●							Ambient Low
				●		●	●	●				●		●	●	●							Ambient High
																							SAND & DUST
										●	●						●	●					Fine Particles
										●	●						●	●					Coarse Particles
																							WIND
										●	●	●	●	●		●	●	●	●	●	●		40 to 100 MPH & Over
																							PRECIPITATION
				●			●			●	●	●		●	●	●	●	●					Rain
							●				●	●		●	●	●	●	●					Snow
							●			●	●	●		●	●	●	●	●					Ice
																							ELECTROMAGNETIC INTERFERENCE (NATURAL)
																							Aurora
																							Static Electricity
																							Lightning
																							Solar Radiation
																							ELECTROMAGNETIC INTERFERENCE (MAN MADE)
																							Generators
																							Vehicle Ignition
																							Prox. of Equip. to Each Other
																							Aircraft
																							PROXIMITY TO SUPPORT & STORAGE FACILITIES
●	●	●								●	●	●	●	●	●	●	●	●	●	●	●		Remote Areas
●	●											●	●	●	●	●	●						Space Consid'ns / Restric'ns
●	●									●	●	●	●	●	●	●	●	●	●	●	●		Vehicle Availability
																							PROXIMITY TO TRANSPORTATION
●	●	●								●	●	●	●	●	●	●	●	●	●	●	●		Remote Areas
●	●									●	●	●	●	●	●	●	●	●	●	●	●		Vehicle Availability
●	●									●	●	●	●	●	●	●	●	●	●	●	●		Road Conditions
																							TRANSPORTATION
										●	●						●	●	●	●	■		Acceleration
										●	●						●	●		■			Shock
										●	●						●	●	■				Vibration
						●				●	●	●	●	●	●	●	●	■					Packaging
										●	●	●	●	●	●	●	■						Handling
				●		●	●	●		●	●	●		●	●	■							Temperature (Control)
				●		●	●	●		●	●	●		●	■								Humidity (Control)

2.

Vehicle Ignition	Prox. of Equip. to Each Other	Aircraft	PROXIMITY TO SUPPORT & STORAGE FACILITIES	Remote Areas	Space Consid'ns / Restric'ns	Vehicle Availability	PROXIMITY TO TRANSPORTATION	Remote Areas	Vehicle Availability	Road Conditions	TRANSPORTATION	Acceleration	Shock	Vibration	Packaging	Handling	Temperature (Control)	Humidity (Control)	Precipitation (Control)	Sand & Dust (Control)	Salt Spray (Control)	Commercial Modes	Military Modes	ARTIFICIAL ENVIRONMENT	Air Conditioning	Heating	Ventilating	CHEMICAL REACTION	Dissimilar Metals	MAINT. PHILOSOPHY	Throw Away At Failure Plan	Repair At Failure Plan	Return At Failure Plan
				●		●		●	●	●		■																					
				●		●		●	●	●		●	■																				
				●		●		●	●	●		●		■																			
				●		●		●	●	●		●	●	●	■																		
				●	●	●		●	●	●		●	●	●	●	■																	
				●	●	●		●	●	●					●	●	■																
				●	●	●		●	●	●					●	●	●	■															
				●	●	●		●	●	●					●	●	●	●	■														
				●	●	●		●	●	●					●	●				■													
				●	●	●		●	●	●					●	●	●	●	●		■												
				●		●		●	●	●		●	●	●	●	●	●	●	●	●	●	■											
				●		●		●	●	●		●	●	●	●	●	●	●	●	●	●		■										
																	●	●				●	●		■								
																	●	●				●	●			■							
															●		●	●				●	●				■						
																	●	●											■				
				●				●														●	●								■		
				●	●	●		●	●	●												●	●									■	
				●	●	●		●	●	●												●	●										■

Figure 6. Continued

3

ENVIRONMENTAL EFFECTS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	EMBRITTLEMENT	GRANULATION	INCREASED VISCOSITY & SOLIDIFICATION	VISCOSITY REDUCTION & EVAPORATION	ICE FORMATION	FALLING ICE	PHYSICAL CONTRACTION	PHYSICAL EXPANSION	THERMAL AGING	PART DETERIORATION & HUMAN INEFFICIENCY	ABSORPTION OF MOISTURE	FUNGUS GROWTH	CORROSION	ERROSION
GEOGRAPHICAL LOCATION														
Ice Cap	●	●	●		●	●	●			●				
Arctic	●	[illegible]	●		●	●	●			●				
Maritime	[illegible]	[illegible]	●	●	●	●	●	●	●	●	●	●	●	●
Continental	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Desert & Steppe		●		●				●	●	●				
Tropical				●				●	●	●	●	●	●	●
Highland	●	●	●		●	●	●	●		●	●	●	●	●
CLIMATIC ENVIRONMENT														
Frigid	●		●		●	●	●							
Tropic				●				●	●	●	●	●	●	●
Temperate	●	●	●	●	●	●	●	●	●	●	●	●	●	●
TERRESTRIAL ENVIRONMENT														
Mountains	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Low Hills	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Valleys	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Flatlands	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Coastal	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MARINE ENVIRONMENT														
Deep Sea	●		●	●	●	●	●	●	●	●	●	●	●	
Off Shore	●		●	●	●	●	●	●	●	●	●	●	●	
Rivers & Lakes	●		●	●	●	●	●	●	●	●	●	●	●	●

ABSORPTION OF MOISTURE	FUNGUS GROWTH	CORROSION	ERROSION	CORROSION, GALVANIC ACTION	ELECTROLYSIS	CLOGGING	ABRASION	FORCE APPLICATION	DEPOSITS FOREIGN MATTER	MECHANICAL STRESS	IMPACT STRESS	BLACKOUT OF SIGNAL	SIGNAL INTERRUPTIONS	NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME
				●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
				●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
				●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
				●		●	●	●	●	●	●	●							●	●
●	●	●	●	●	●	●	●	●	●	●	●	●							●	●
●	●	●	●	●	●	●	●	●	●	●	●	●								
●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●
●	●	●		●	●			●		●	●	●	●					●	●	●
●	●	●		●	●			●		●	●	●	●					●	●	●
●	●	●	●	●	●	●		●	●	●	●	●	●					●	●	●

Figure 7. Relationships

2

BLACKOUT OF SIGNAL	SIGNAL INTERRUPTIONS	NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	DECREASED RATE OF TRAVEL	INEFFECTIVE PROTECTION	LARGE SPARES (PHYSICAL SIZE)STORAGE	SOLE SOURCE SUPPLY	MORE DIVERSITY IN SPARES	HIGHER MAINTENANCE SKILL LEVEL REQUIRED	GREATER REPAIR TIME REQUIRED	TEST EQUIPMENT REQUIRED	MULTI LEVEL MAINTENANCE	PIPELINE TO CONTRACTOR REQUIRED	LARGE NUMBER OF HIGH LEVEL SPARES REQUIRED
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
●							●	●	●	●				●	●	●	●		
●							●	●	●	●				●	●	●	●		
●																			
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		
●	●					●	●	●	●	●				●	●	●	●		

Figure 7. Relationships of Pertinent Environmental Factors and Subfactors to Environmental Effects

3

ENVIRONMENTAL EFFECTS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	EMBRITTLEMENT	GRANULATION	INCREASED VISCOSITY & SOLIDIFICATION	VISCOSITY REDUCTION & EVAPORATION	ICE FORMATION	FALLING ICE	PHYSICAL CONTRACTION	PHYSICAL EXPANSION	THERMAL AGING	PART DETERIORATION & HUMAN INEFFICIENCY	ABSORPTION OF MOISTURE	FUNGUS GROWTH	CORROSION	ERROSION	CORROSION, GALVANIC ACTION
TEMPERATURE															
Ambient Low	●		●		●	●	●			●					
Ambient High				●				●	●	●	●	●	●		●
HUMIDITY															
Ambient Low	●	●													
Ambient High										●	●	●	●		
SAND & DUST															
Fine Particles															
Coarse Particles															
WIND															
40 to 100 MPH & Over					●	●				●					
PRECIPITATION															
Rain										●	●	●	●	●	
Snow	●		●		●	●	●			●	●		●		
Ice	●		●		●	●	●			●	●		●		
ELECTROMAGNETIC INTERFERENCE (NATURAL)															
Aurora															
Static Electricity															
Lightning															
Solar Radiation															

ERROSION	CORROSION, GALVANIC ACTION	ELECTROLYSIS	CLOGGING	ABRASION	FORCE APPLICATION	DEPOSITS FOREIGN MATTER	MECHANICAL STRESS	IMPACT STRESS	BLACKOUT OF SIGNAL	SIGNAL INTERRUPTIONS	NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	DECREASED RATE OF TRAVEL	INEFFECTIVE PROTECTION	LARGE SPARES (PHYSICAL SIZE) STORAGE
			●	●	●	●	●	●								●	●	●		
	●	●							●											
		●																		
			●	●		●														
			●	●		●														
			●	●		●										●	●	●		
●		●	●							●						●	●	●		
			●	●		●										●	●	●		
			●			●			●	●						●	●	●		
									●	●	●									
										●	●									
										●		●	●							
									●		●	●								

2

NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	DECREASED RATE OF TRAVEL	INEFFECTIVE PROTECTION	LARGE SPARES (PHYSICAL SIZE) STORAGE	SOLE SOURCE SUPPLY	MORE DIVERSITY IN SPARES	HIGHER MAINTENANCE SKILL LEVEL REQUIRED	GREATER REPAIR TIME REQUIRED	TEST EQUIPMENT REQUIRED	MULTI LEVEL MAINTENANCE	PIPELINE TO CONTRACTOR REQUIRED	LARGE NUMBER OF HIGH LEVEL SPARES REQUIRED
					●	●	●										
					●	●	●										
					●	●	●										
					●	●	●										
					●	●	●										
●																	
●																	
	●	●															
●	●																

Figure 7. Continued

3

ENVIRONMENTAL EFFECTS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	EMBRITTLEMENT	GRANULATION	INCREASED VISCOSITY & SOLIDIFICATION	VISCOSITY REDUCTION & EVAPORATION	ICE FORMATION	FALLING ICE	PHYSICAL CONTRACTION	PHYSICAL EXPANSION	THERMAL AGING	PART DETERIORATION & HUMAN INEFFICIENCY	ABSORPTION OF MOISTURE	FUNGUS GROWTH	CORROSION	ERROSION	CORROSION, GALVANIC
ELECTROMAGNETIC INTERFERENCE (MAN MADE)															
Generators															
Vehicle Ignition															
Prox. of Equip. to Each Other															
Aircraft															
PROXIMITY TO SUPPORT & STORAGE FACILITIES															
Remote Areas															
Space Consid'ns / Restric'ns															
Vehicle Availability															
PROXIMITY TO TRANSPORTATION															
Remote Areas															
Vehicle Availability															
Road Conditions															

CORROSION	ERROSION	CORROSICN, GALVANIC ACTION	ELECTROLYSIS	CLOGGING	ABRASION	FORCE APPLICATION	DEPOSITS FOREIGN MATTER	MECHANICAL STRESS	IMPACT STRESS	BLACKOUT OF SIGNAL	SIGNAL INTERRUPTIONS	NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	DECREASED RATE OF TRAVEL	INEFFECTIVE PROTECTION	LARGE SPARES (PHYSICAL
											●			●							
											●			●							
															●	●					
											●				●						
																	●	●	●		●
																		●			
																	●	●	●		
																	●	●	●		
																	●	●	●		
																	●	●	●		

2

BLACKOUT OF SIGNAL	SIGNAL INTERRUPTIONS	NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	DECREASED RATE OF TRAVEL	INEFFECTIVE PROTECTION	LARGE SPARES (PHYSICAL SIZE) STORAGE	SOLE SOURCE SUPPLY	MORE DIVERSITY IN SPARES	HIGHER MAINTENANCE SKILL LEVEL REQUIRED	GREATER REPAIR TIME REQUIRED	TEST EQUIPMENT REQUIRED	MULTI LEVEL MAINTENANCE	PIPELINE TO CONTRACTOR REQUIRED	LARGE NUMBER OF HIGH LEVEL SPARES REQUIRED
	●			●															
	●			●															
					●	●													
	●				●														
							●	●	●		●	●	●	●	●	●	●	●	●
								●						●	●	●	●	●	
							●	●	●					●	●		●		
							●	●	●				●	●	●	●		●	
							●	●	●					●	●		●	●	
							●	●	●					●	●		●	●	

Figure 7. Continued

3

ENVIRONMENTAL EFFECTS vs. PERTINENT ENVIRONMENTAL FACTORS & SUBFACTORS	EMBRITTLEMENT	GRANULATION	INCREASED VISCOSITY & SOLIDIFICATION	VISCOSITY REDUCTION & EVAPORATION	ICE FORMATION	FALLING ICE	PHYSICAL CONTRACTION	PHYSICAL EXPANSION	THERMAL AGING	PART DETERIORATION & HUMAN INEFFICIENCY	ABSORPTION OF MOISTURE	FUNGUS GROWTH	CORROSION	ERROSION	CORROSION, GALVANIC ACTION
TRANSPORTATION															
Acceleration															
Shock															
Vibration															
Packaging															
Handling															
Temperature (Control)	●	●			●		●	●				●	●		
Humidity (Control)											●	●	●		
Precipitation (Control)					●						●	●	●		
Sand & Dust (Control)															
Salt Spray (Control)											●	●			
Commercial Modes															
Military Modes															
ARTIFICIAL ENVIRONMENT															
Air Conditioning								●	●	●	●	●	●		
Heating							●		●	●	●	●	●		
Ventilating								●	●	●	●	●	●		
CHEMICAL REACTION															
Dissimilar Metals															●
MAINT. PHILOSOPHY															
Throw Away At Failure Plan															
Repair At Failure Plan															
Return At Failure Plan															

ABSORPTION OF MOISTURE	FUNGUS GROWTH	CORROSION	ERROSION	CORROSION, GALVANIC ACTION	ELECTROLYSIS	CLOGGING	ABRASION	FORCE APPLICATION	DEPOSITS FOREIGN MATTER	MECHANICAL STRESS	IMPACT STRESS	BLACKOUT OF SIGNAL	SIGNAL INTERRUPTIONS	NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	[illegible]
										●	●										
										●	●										
										●	●										
										●	●										
										●	●										
	●	●																			
●	●	●																			
●	●	●				●															
						●	●		●												
●	●																				
																			●	●	
																			●	●	
●	●	●																			
●	●	●																			
●	●	●																			
				●																	

NOISE	STATIC	SPORADIC NOISE	NOISE & SIGNAL DISTORTIONS	RFI PROBLEMS	INCREASED TRAVEL TIME	INCREASED DELAY TIME	DECREASED RATE OF TRAVEL	INEFFECTIVE PROTECTION	LARGE SPARES (PHYSICAL SIZE) STORAGE	SOLE SOURCE SUPPLY	MORE DIVERSITY IN SPARES	HIGHER MAINTENANCE SKILL LEVEL REQUIRED	GREATER REPAIR TIME REQUIRED	TEST EQUIPMENT REQUIRED	MULTI LEVEL MAINTENANCE	PIPELINE TO CONTRACTOR REQUIRED	LARGE NUMBER OF HIGH LEVEL SPARES REQUIRED
								●									
								●									
								●									
								●									
								●									
					●	●											
					●	●											
									●	●	●						
												●	●	●	●		
																●	

Figure 7. Continued

3

e. Relationships of Pertinent Environmental Factors and Subfactors to Environmental Effects

Once the relationships of Environmental Factors to each other were developed, it was necessary to illustrate the relationships of Environmental Factors and Subfactors to Environmental Effects. An Environmental Effect is defined as a condition which causes a degradation of Systems Effectiveness as the result of the influence of an Environmental Factor or Subfactor. For example, Environmental Factor, Temperature and related Subfactor, Ambient Low, have a direct effect on the viscosity of lubricating oil causing the oil to loose its properties. One of the Environmental Effects of Abmient Low Temperatures, therefore, is increased viscosity and solidification of oil. The matrix shown in Figure 7 was developed to show these relationships.

The matrix illustrates the relationships of all practical combinations that can exist between Pertinent Environmental Factors and related Subfactors and Environmental Effects found to have a degrading affect on system performance. The matrix was constructed in such a manner as to provide systems planners and designers with all significant variables of Environmental Effects (identified through literature search and the survey program) that should be considered when planning or designing a system.

f. Relationships of Pertinent Environmental Factors and Subfactors to Environmental Effects, to System Performance, and to System Performance Characteristics

The final task in the analysis of environmental data was to relate Environmental Factors and Subfactors and Environmental Effects and resultant relationships between these Environmental Effects and System Performance, and affects of System Performance on System Performance Characteristics. The purpose of this analysis was two-fold: 1) to provide the means by which system planners and designers could establish a direct link between Pertinent Environmental Factors and degradation of System Perfor-

mance Characteristics; and 2) to illustrate how a system to be operated in a given Geographical Location with established Climatic, Terrestrial, and Marine Environment could be expected to perform under existing environmental conditions. This analysis resulted in the development of Table II which illustrates these relationships.

8. HYPOTHETICAL EXAMPLE DEMONSTRATING THE APPLICATION OF RESULTS OF THE INVESTIGATION OF ENVIRONMENTS

A hypothetical example of how environmental data are developed and how Geographical Locations, Climate, Temperature, and Maintenance, etc., Influence Systems Effectiveness is presented below. This example demonstrates how the results of the investigation of environments can be applied to system planning and design.

For this example, assume a hypothetical ground electronic system (comprised of Radar, Tropospheric Scatter, and HF Radio) is to be located in the European Alps (Northern Italy). General climatic conditions that exist in this area are discussed in paragraph 7a and are illustrated in Figure 4.

<u>Step 1</u>. Identify and list from Figure 3, the Environmental Factors, both Natural and Man Made, that are believed to be most applicable to the system.

Since the hypothetical system is located in the Alps, the most prevalent factors to be listed are Geographical Location, Climatic Environment, Terrestrial Environment, Temperature, Wind, Precipitation, Proximity to Support and Storage Facilities, and Proximity to Transportation.

<u>Step 2</u>. Identify and list from Table I, all applicable Environmental Subfactors that appear under the Environmental Factors previously identified from Figure 3.

The Subfactors to be listed for the hypothetical system are as follows:

Table II. Relationships of Pertinent Environmental Factors and Subfa
to System Performance and to System Perform

PERTINENT ENVIRONMENTAL FACTORS AND SUBFACTORS	ENVIRONMENTAL EFFECTS	EFFECTS ON SYSTEMS PERFORMANCE
NATURAL ENVIRONMENTS		
TEMPERATURE Ambient Low	Embrittlement	Loss of mechanical strength, cracking and fractures of structures (Tower and Antennas).
	Increased Viscosity and Solidification	Loss of lubrication properties, oil and grease.
	Ice Formation	Electrical properties altered. Falling ice damage to waveguides and shelters.
	Physical Contraction	Increased wear on moving parts (gears, bearings, etc.). Loss of mechanical strength.
TEMPERATURE Ambient High	Viscosity Reduction and Evaporation	Loss of lubricating properties. Breakdown and oxidation of oil and grease.
	Thermal Aging	Structural weakness (Towers, Antennas). Insulation breakdown. Alteration of electrical properties.
	Physical Expansion	Increased wear on moving parts (gears, bearings, etc.). Increased mechanical stress.
HUMIDITY Ambient Low	Embrittlement	Loss of mechanical strength. Structural weakness.
	Granulation	Alteration of electrical properties.
HUMIDITY Ambient High	Absorption of Moisture	Swelling and rupture of material.

rtinent Environmental Factors and Subfactors to Environmental Effects
stem Performance and to System Performance Characteristics

FECTS ON SYSTEMS PERFORMANCE	EFFECT ON PERFORMANCE CHARACTERISTICS: INPUT										OUTPUT								
	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface	Prime Power	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface
of mechanical strength, cracking and tures of structures (Tower and Antennas).	●		●	●			●	●			●		●	●			●	●	
of lubrication properties, oil and grease.	●			●			●			●	●			●			●		
rical properties altered. Falling ice age to waveguides and shelters.	●	●		●			●				●	●		●			●		
ased wear on moving parts (gears, bear-, etc.). Loss of mechanical strength.	●	●					●			●	●	●		●			●		
of lubricating properties. Breakdown and dation of oil and grease.	●			●						●	●			●					
tural weakness (Towers, Antennas). In-tion breakdown. Alteration of electrical perties.	●	●	●	●		●	●				●	●	●	●		●	●		
ased wear on moving parts (gears, bear-, etc.). Increased mechanical stress.	●			●			●			●	●			●			●		
of mechanical strength. Structural kness.	●		●	●		●	●			●	●		●	●		●	●		
ation of electrical properties.	●			●			●	●			●		●		●		●	●	
ling and rupture of material.	●	●		●			●	●		●	●	●		●			●	●	

2

Table II. Continued

PERTINENT ENVIRONMENTAL FACTORS AND SUBFACTORS	ENVIRONMENTAL EFFECTS	EFFECTS ON SYSTEMS PERFORMANCE	Loss
HUMIDITY (Cont) Ambient High	Fungus Growth	Breakdown of material strength. Induces cross-talk.	
	Corrosion	Breakdown of mechanical strength. Reduction or resistance. Induces electrical leakage.	●
	Electrolysis	Loss of electrical properties. Increased conductivity.	●
SAND AND DUST Fine and Coarse Particles	Clogging	Increased wear on moving parts (gears, bearings, etc.).	●
	Abrasion	Wears away paint and protective finishes.	
SALT, FOG AND SPRAY Degree of Concentration	Corrosion	Breakdown of mechanical strength.	●
	Electrolysis	Loss of electrical properties.	●
WIND 40 to 100 MPH; 100 MPH and Over	Force Application	Bends, warps, creates structural collapse.	●
	Deposits Foreign Material	Creates clogging, which results in increased wear on moving parts.	●
PRECIPITATION Rain, Snow, Ice	Errosion	Weakens and undermines structures, creates flooding, collapses structures. Electrical failure.	●
	Corrosion	Breakdown of mechanical strength.	●

E	EFFECT ON PERFORMANCE CHARACTERISTICS																		
	INPUT										OUTPUT								
	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface	Prime Power	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface
cross-				●		●	●		●					●		●	●		●
ction e.	●	●	●	●		●	●		●	●	●	●	●	●	●	●	●		●
con-	●				●		●		●	●					●		●		●
ear-	●			●					●	●	●			●					●
s.									●										●
	●	●	●	●		●	●		●	●	●	●	●	●		●	●		●
	●				●		●		●	●					●		●		●
e.	●		●	●			●	●			●		●	●			●	●	
osed	●			●						●	●			●					●
ates cal	●			●			●			●	●			●			●		
	●	●	●	●		●	●		●	●	●	●	●	●		●	●		●

2

Table II. Continued

PERTINENT ENVIRONMENTAL FACTORS AND SUBFACTORS	ENVIRONMENTAL EFFECTS	EFFECTS ON SYSTEMS PERFORMANCE
PRECIPITATION (Cont)		
Rain, Snow, Ice	Falling Ice	Damages waveguides and shelters. Personnel safety hazard.
ELECTROMAGNETIC INTERFERENCE		
Aurora	Blackouts of Signal	Complete loss of transmit or receive capability.
Static Electricity	Noise	Garble transmission or receiving capability.
Lightning	Signal Interruptions	Power interruptions, loss of transmit or receive.
Solar Radiation	Static and Blackouts	Interruptions of transmit or receive, alteration of electrical properties.
MAN MADE ENVIRONMENT		
ELECTROMAGNETIC INTERFERENCE		
Generators	Sporadic Noise	Garbling and complete loss of signal.
Vehicle Ignition	Sporadic Noise	Signal distortion and interruption.
Proximity Equip. to Each Other	RFI Problems	Over riding, loss of signal.
Aircraft	Noise and Signal Distortion	Temporary loss of receive signal.
PROXIMITY TO SUPPORT & STORAGE FACILITIES		
Remote Areas	Increased Travel Time	Receipt of material delayed due to storage facilities. To far from site. Increased time to repair.

Table II. Continued

EFFECTS ON SYSTEMS PERFORMANCE	EFFECT ON PERFORMANCE CHARACTERISTICS																			
	INPUT										OUTPUT									
	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface	Prime Power	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface	
Damages waveguides and shelters. Personnel safety hazard.	●	●		●			●				●	●		●			●			
Complete loss of transmit or receive capability.	●	●				●	●				●	●			●	●	●			
Garble transmission or receiving capability.	●			●		●	●				●			●	●	●				
Power interruptions, loss of transmit or receive.	●	●				●	●			●	●	●				●	●			
Interruptions of transmit or receive, alteration of electrical properties.	●	●				●	●				●	●		●	●	●				
Garbling and complete loss of signal.	●	●				●	●				●	●			●	●	●			
Signal distortion and interruption.	●	●				●	●				●	●				●	●			
Over riding, loss of signal.	●	●	●	●							●	●	●	●						
Temporary loss of receive signal.	●	●					●				●	●					●			
Receipt of material delayed due to storage facilities. To far from site. Increased time to repair.	●		●	●				●	●		●		●	●				●	●	

2

Table II. Continued

PERTINENT ENVIRONMENTAL FACTORS AND SUBFACTORS	ENVIRONMENTAL EFFECTS	EFFECTS ON SYSTEMS PERFORMANCE
PROXIMITY TO SUPPORT & STORAGE FACILITIES (Cont)		
Space Considerations & Restrictions	Increased Delay Time	Increased time to repair and downtime due to lack of on-site spares.
Vehicle Availability	Increased Delay Time	Increased repair times due to unavailability of vehicles or excessive distance from ports and airfield.
PROXIMITY TO TRANSPORTATION		
Remote Areas	Increased Travel Time	Increased repair time due to transportation of material into remote areas.
Vehicle Availability	Increased Delay Time	Increased repair times and downtime due to unavailability of vehicles or requirements for special types of vehicles (snowcats, land rover, jeeps).
Road Conditions	Decreased Rate of Travel	Increased repair times and downtime due to poor road conditions, rough terrain.
TRANSPORTATION		
Acceleration	Mechanical Stress	Equipment damage and breakage.
Shock	Mechanical Stress	Damage, misalignment, breakage.
Vibration	Mechanical Stress	Loss of mechanical strength, structural failure.
Packaging	Ineffective Protection	Damage to equipment, structures, etc.
Handling	Impact Stress From Rough Treatment	Damage to equipment, structures, etc.

Table II. Continued

SYSTEMS PERFORMANCE	Input: Loss	Input: Level	Input: Error	Input: Accuracy	Input: Ambiguity	Input: Resolution	Input: Distortion	Input: Modes	Input: Man-Mach. Interface	Input: Prime Power	Output: Loss	Output: Level	Output: Error	Output: Accuracy	Output: Ambiguity	Output: Resolution	Output: Distortion	Output: Modes	Output: Man-Mach. Interface
to repair and downtime due to e spares.	●		●	●					●		●		●	●				●	
r times due to unavailability of cessive distance from ports and	●		●	●					●		●		●	●				●	
r time due to transportation of emote areas.	●		●	●				●	●		●		●	●			●	●	
r times and downtime due to of vehicles or requirements es of vehicles (snowcats, land	●		●	●				●	●		●		●	●			●	●	
r times and downtime due to ditions, rough terrain.	●		●	●				●	●		●		●	●			●	●	
age and breakage.	●	●	●	●			●			●	●	●	●	●			●		
ignment, breakage.	●	●	●	●		●	●			●	●	●	●	●		●	●		
ical strength, structural failure.	●	●	●	●		●	●			●	●	●	●	●		●	●		
ipment, structures, etc.	●	●	●	●		●	●				●	●	●	●		●	●		
ipment, structures, etc.	●	●	●	●		●	●				●	●	●	●		●	●		

2

Table II. Continued

PERTINENT ENVIRONMENTAL FACTORS AND SUBFACTORS	ENVIRONMENTAL EFFECTS	EFFECTS ON SYSTEMS PERFORMANCE	Loss	Level
TRANSPORTATION (Cont)				
Temperature (Control)	Embrittlement of Thermal Aging	Loss of mechanical strength or component degradation.	●	●
Humidity (Control)	Fungus and Moisture	Breakdown of material strength.		
Precipitation (Control)	Corrosion	Breakdown of mechanical strength.	●	●
Sand and Dust (Control)	Clogging	Increased wear on moving parts.	●	
Salt Spray (Control)	Corrosion and Oxidation	Breakdown of mechanical strength.	●	●
Commercial Modes	Increased Delay Time	Airfields, seaports, great distances from remote areas, delay receipt of material.	●	
Military Modes	Increased Delay Time	Schedules, non-regulated, priorities difficult to obtain delay receipt of material.	●	
ARTIFICIAL ENVIRONMENT				
Air Conditioning	Component Deterioration and Human Inefficiency	Components degrade due to thermal aging (excessive heat or cold).	●	●
Heating	Component Deterioration and Human Inefficiency	Human inefficiency due to improper temperature control. Judgment errors, and mistakes made as result of thermal fatigue (heat or cold).	●	
Ventillating	Component Deterioration and Human Inefficiency	Same as Heating		
CHEMICAL REACTION				
Dissimilar Metal	Corrosion Due to Galvanic Action	Weakens joints, interfaces, reduces material strength, alters electrical properties.	●	●

Table II. Continued

...TS	EFFECTS ON SYSTEMS PERFORMANCE	EFFECT ON PERFORMANCE CHARACTERISTICS: INPUT										OUTPUT								
		Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface	Prime Power	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface
	Loss of mechanical strength or component degradation.	●	●	●	●		●	●				●	●	●	●		●	●		
	Breakdown of material strength.				●		●	●		●					●		●	●		●
	Breakdown of mechanical strength.	●	●	●	●		●	●		●	●	●	●	●	●		●	●		●
	Increased wear on moving parts.	●			●					●	●	●			●					●
	Breakdown of mechanical strength.	●	●	●	●		●	●		●	●	●	●	●	●		●	●		●
	Airfields, seaports, great distances from remote areas, delay receipt of material.	●								●		●								●
	Schedules, non-regulated, priorities difficult to obtain delay receipt of material.	●								●		●								●
...and	Components degrade due to thermal aging (excessive heat or cold).	●	●	●	●					●		●	●	●	●					●
...and	Human inefficiency due to improper temperature control. Judgment errors, and mistakes made as result of thermal fatigue (heat or cold).	●		●	●					●		●		●	●					●
...and	Same as Heating																			
...c	Weakens joints, interfaces, reduces material strength, alters electrical properties.	●	●	●	●		●	●				●	●	●	●		●	●		

2

Table II. Continued

PERTINENT ENVIRONMENTAL FACTORS AND SUBFACTORS	ENVIRONMENTAL EFFECTS	EFFECTS ON SYSTEMS PERFORMANCE	EFF			
			Loss	Level	Error	Accuracy
MAINTENANCE PHILOSOPHY Throw Away at Failure Plan	Large Spares (Physical Size) Storage	Few spares available, increased downtime.	●		●	●
	Sole Source Supply	Delay time greater, increased downtime.	●		●	●
	More Diversity in Spares	Delay time greater, increased downtime.	●		●	●
Repair at Failure Plan	Higher Maintenance Skill Level Required	Delay time greater, increased downtime.	●		●	●
	Greater Repair Time Required	Increased downtime.	●		●	●
	Test Equipment Required	Test equipment maintenance required.	●		●	●
	Multi Level Maintenance	Delay time greater, increased downtime.	●		●	●
Return to Supplier at Failure Plan	Pipeline to Contractor Required. Larger Number of Higher Level Spares Required	Delay time greater due to shipping, lead time, and transportation. Results in increased downtime.	●		●	●

Table II. Continued

ECTS ON SYSTEMS PERFORMANCE	EFFECT ON PERFORMANCE CHARACTERISTICS																		
	INPUT										OUTPUT								
	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface	Prime Power	Loss	Level	Error	Accuracy	Ambiguity	Resolution	Distortion	Modes	Man-Mach. Interface
pares available, increased downtime.	●		●	●					●		●		●	●					●
time greater, increased downtime.	●		●	●					●		●		●	●					●
time greater, increased downtime.	●		●	●					●		●		●	●					●
time greater, increased downtime.	●		●	●					●		●		●	●					●
sed downtime.	●		●	●					●		●		●	●					●
quipment maintenance required.	●		●	●					●		●		●	●					●
time greater, increased downtime.	●		●	●					●		●		●	●					●
time greater due to shipping, lead time, transportation. Results in increased down- .	●		●	●					●		●		●	●					●

2

Geographical Location
Maritime
Highland

Climatic Environment
Frigid

Terrestrial Environment
Mountainous

Temperature
Ambient Low

Wind
40 MPH to 100 MPH

Precipitation
Snow

Proximity to Support and Storage Facilities
Space Considerations and Restrictions

Proximity to Transportation
Road Conditions
Shock and Vibration
Temperature Control
Preciptiation Control

The following are examples of the rationale that was used in the identification of the above Environmental Subfactors. Precipitation in the form of snow reaches great depths in the Alps causing roads to become blocked; when travel can be resumed, it is often under hazardous conditions. Space Considerations and Restrictions are inherent problems because sites are on mountain peaks and the land area on the peaks is limited. Shock and Vibration problems can be prevalent because bringing in materials to the sites by vehicles over rough terrain under adverse weather conditions will subject the material to rough handling.

Step 3. Review the Environmental Factors and Subfactors identified and compare them with those factors presented in Figure 5. (System planners and designers should add any other Pertinent Environmental Factors and related for Subfactors to the list which they know would have a significant or critical influence on the specific system under consideration.) The factors appearing in Figure 5 represent those factors that were found to have

a significant or critical influence on the effectiveness of ground electronic systems. The purpose of the comparison is to provide a means to determine and evaluate those factors which are considered significant or critical.

Step 4. Locate those Environmental Factors and Subfactors identified on the ordinate of Figure 6. Proceed along the abscissa of Figure 6 and list all the Environmental Factors and Subfactors that have a relationship to the factors identified.

For the hypothetical system, Road Conditions, a Subfactor of Proximity to Transportation, is used as an example. This Subfactor has a relationship to Highlands, Frigid Climate, Mountains, Snow, Remote Areas, Space Considerations, and Vehicle Availability. This indicates that there is an important interplay between the Subfactor, Road Conditions, and all the other Subfactors identified.

Step 5. Locate those Environmental Factors and Subfactors identified on the ordinate of Figure 7. Proceed along the abscissa of Figure 7 and list all the Environmental Effects that have a relationship to the factors identified.

For the hypothetical system, Road Conditions, for example, will present certain Environmental Effects. These effects are shown in Figure 7 as: Increased Travel Time (due to poor roads, rough terrain, bad weather); Increased Delay Time (excessive time to move supplies and materials); Decreased Rate of Travel Time (due to poor weather), etc.

Step 6. Locate in the column headed Pertinent Environmental Factors and Subfactors in Table II, those Environmental Factors and Subfactors previously identified. Record the corresponding remarks in each of the adjacent columns headed, "Environmental Effects," "Effect on System Performance," and "Effects on System Performance Characteristics."

The listing of these data for the hypothetical system will include, for example, Proximity to Transportation Subfactors: Remote Areas, Vehicle Availability, Road Conditions. The Environmental Effects for Road Conditions were determined to be Decreased Rate of Travel. The effects on system performance are increased repair time and system downtime due to poor roads and rough terrain. The Performance Characteristics affected because supplies or materials and equipment spares will be delayed due to poor roads and rough terrain will be the loss of input signals, errors, degradation of input accuracy, prime power failures due to lack of diesel fuel for generators, and output losses in signals and levels.

The hypothetical example has shown how environmental data developed for Geographical Location, Climate, Temperature, Maintenance , etc. have an affect on Systems Effectiveness. It also showed examples of the effects on the system and the system performance characteristics.

System planners and designers, when using the method discussed in the preceding paragraphs, can apply safeguards to circumvent those Environmental Factors and their Environmental Effects that will degrade system performance and overall Systems Effectiveness.

9. REQUIREMENTS FOR SYSTEMS EFFECTIVENESS PROGRAM

The requirements for Systems Effectiveness Program were based on the systems effectiveness study. The results of the study, as documented in this Technical Report, provides useful information for system planners and designers to make them aware of the various Systems Effectiveness elements that should be considered throughout the system development cycle. However, to enable the Air Force to make optimum use of this information in practice, it is necessary to have system planners and designers actually apply this information during the planning and designing stages of system development. To provide guidelines for program development, Federal Electric Corporation formulated a document entitled,

"Requirements for a Systems Effectiveness Program (Ground Electronic Equipment).". This document, containing systems effectiveness guidelines, is presented in Appendix V. The document includes the following:

1. General Requirements — overall requirements for a Systems Effectiveness Program and Program Plan.

2. Detailed Requirements — specific requirements for the program elements and the program plan.

3. Integration Requirements — requirements concerning the integration of the system under development and other equipment, such as government furnished equipment.

4. Requirements for Intended Use

5. Data Requirements

SECTION III
CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

1. The study resulted in the development of an organized and integrated approach for optimization of Systems Effectiveness.

2. The principal output of this study is documented in "Requirements for a Systems Effectiveness Program," (Appendix V) which provides uniform criteria for Systems Effectiveness Programs and guidelines for the preparation of Systems Effectiveness Program Plans.

3. The "Requirements for a Systems Effectiveness Program," is applicable to ground electronic systems since the study was limited to this type of system.

2. RECOMMENDATIONS

Based on the results of investigations and analyses performed during this study, the following recommendations are made:

1. The "Requirements for a Systems Effectiveness Program," (Appendix V) should be imposed as a requirement during the development of a future ground electronic system. Implementation of this recommendation would provide the means for validating the soundness of the approach and provide insight into any areas that might require modification. It should be noted that application of the document to certain equipment development programs could also achieve the same result.

2. Research and development of means for quantifying Systems Effectiveness should be continued and expanded.

3. Research and development of means for determining the cost aspect of Systems Effectiveness should be continued and expanded. This effort should be integrated with the results of the study reported herein.

4. Investigation and study similar to the type reported herein should be initiated on systems other than ground electronic systems.

APPENDIXES

APPENDIX I

Systems Effectiveness Survey Form

SYSTEMS EFFECTIVENESS SURVEY FORM

General Instructions

This Systems Effectiveness Survey Form was develop to obtain information concerning specific factors that influence mission accomplishment, fro rsonnel with experience like yours in systems operation, maintenance, and logistics.

Your responses, based on personal, recent experience w h major systems, should be gauged by the following criteria:

1. Your knowledge of a particular major system should indicate that certain factors have had an adverse effect on the system, and ultimately an adverse effect on the mission.

2. Each factor having an adverse effect on the system will affect the system, and ultimately the mission in varying degrees.

The objective of the survey is to identify all of the factors that adversely affect mission accomplishment and to determine the relative effect of each factor on mission accomplishment. We wish to emphasize that the objective of this survey should be kept in mind as you respond to each factor.

To begin, answer the following general questions. An instruction is included below each general question.

1. DATE ____________
   (Enter the date that you complete the form)

2. LOCATION ____________
   (Enter your geographic location. For example, Western Test Range, California)

3. ACTIVITY ____________
   (Indicate your primary area of activity, such as, operations, maintenance, or logistics)

4. NAME ____________
   (Enter your name)

5. POSITION ____________
   (Enter your title or function. For example, Manager, Operations)

6. MAJOR SYSTEM ____________
   (Indicate Major System to which your personal experience applies. For example, Early Warning System)

FEX-146

7. YEARS OF DIRECT EXPERIENCE ON MAJOR SYSTEM ______________
(Indicate the number of years of direct personal experience that you have on the system identified in 6 above)

8. SUBSYSTEM TYPE

COMMUNICATION_____ RADAR_____ COMPUTER____ MISSILE SUPPORT_____

a) Indicate subsystem to which your personal experience applies, by checking the appropriate subsystem type)

b) If your experience is applicable to more than one subsystem, use a separate form for each subsystem type)

NOTE: Only one subsystem type should be checked on each survey form.

9. TYPICAL EQUIPMENT NOMENCLATURES ______________________________

____

____

(Identify typical equipment nomenclatures that are part of the subsystem checked in 8 above. For example, if radar were checked, AN/FPS-16 might be a typical equipment nomenclature)

Specific Instructions

The remainder of the form is arranged in a check-off format. Specific factors are arranged in groups. For each group of specific factors, such as Group 1, Mission Oriented Factors, respond as follows:

1. If you have no knowledge of a specific factor, place a check mark (✓) in the first column opposite that factor. Whenever you place a check mark in the first column, disregard the remaining columns to the right and proceed to the next specific factor. For example, if you have no knowledge of the first specific factor, Mission Tolerances Narrow, place a (✓) in the first column and proceed to the second specific factor, Mission Tolerances Broad.

2. If a specific factor is not applicable to the system you identified in question six on the first page, place a check mark (✓) in the second column opposite that factor. Whenever you place a check mark in the second column, disregard the remaining columns to the right and proceed to the next factor.

3. If a specific factor does apply to the system you identified in question six on the first page, disregard the first two columns and place a check mark (✓) in one of the four remaining columns opposite that factor, based on the following:

a. If the specific factor that applies to your system has no adverse effect on the system, place a check mark (✓) in the "None" column opposite that factor.

b. If the specific factor that applies to your system has a minimal adverse effect on the system, place a check mark (✓) in the "Minimal" column opposite that factor.

c. If the specific factor that applies to your system has a significant adverse effect on the system, place a check mark (✓) in the "Significant" column opposite that factor.

d. If the specific factor that applies to your system has a critical adverse effect on the system, place a check mark (✓) in the "Critical" column opposite that factor.

4. Additional Factors – Group X is provided to permit you to list other specific factors that you know have an adverse effect on the system, but are not found in Groups I through IX. For each specific factor that you include in Group X, place a check mark (✓) in the "Minimal", "Significant", or "Critical" column opposite that factor.

NOTE: Enter only one check mark (✓) for each factor listed.

GROUP I MISSION ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Mission Tolerances-Narrow	15	4	3	24	19	14
2. Mission Tolerances-Broad	16	32	8	15	8	0
3. Mission Recovery Time-Short	13	21	6	26	9	4
4. Mission Recovery Time-Long	13	39	6	8	8	5
5. Mission Accuracy-Low	13	38	6	9	5	6
6. Mission Accuracy-High	12	15	7	12	16	17
7. Mission Frequency-Low	13	37	12	13	3	1
8. Mission Frequency-High	12	16	7	18	21	5
9. Mission Repeatability-Low	14	38	7	10	4	4
10. Mission Repeatability-High	15	20	6	19	7	10
11. Mission Highly Specialized	13	22	3	12	10	19
12. Mission Routine	13	28	17	13	7	1
13. Mission Goals-Numerous	12	36	6	7	14	4
14. Mission Goals-Not Clearly Defined	11	41	7	2	9	9
15. Mission Goals-Ambiguous	11	44	5	5	9	7
16. Mission Length-Long	8	9	12	9	30	9
17. Mission Length-Short	9	40	7	15	2	4

GROUP II HARDWARE ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Reliability-Low	4	30	5	11	17	13
2. No Redundancy or Backup	2	39	10	6	10	13
3. Redundancy or Backup-Insufficient	3	21	8	14	24	11
4. Electrical Stress-High (e.g., Part or Circuit stress)	10	21	20	23	22	2
5. Mechanical Stress-High	11	31	9	14	12	1
6. System Thermal Stress-High Temp.	12	18	5	22	11	11
7. System Thermal Stress-Low Temp.	13	25	9	23	2	8
8. Use of Non-Standard Parts	4	20	8	27	15	5
9. Use of Microelectronic Devices	15	43	11	8	3	0
10. System Electrical Tolerances-Narrow (e.g., Radar Power Output 1 KW 5%)	9	7	10	9	29	5
11. System Electrical Tolerances-Broad (e.g., Radar Power Output 1 KW 20%)	11	23	17	20	7	3
12. System Mechanical Tolerances-Narrow (e.g., Mechanical Clearance .005 in.)	14	29	6	20	10	3
13. System Mechanical Tolerances-Broad (e.g., Mechanical Clearance .250 in.)	14	34	13	7	10	3

GROUP II HARDWARE ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
14. Shock-Severe	9	32	6	14	12	7
15. Vibration-Severe	9	33	6	13	9	9
16. Useof Encapsulated parts Assemblies, Components	12	27	12	15	13	1
17. Use of Embedded parts, Assemblies, Components	13	28	10	16	12	1
18. Use of Potted Parts, Assemblies, Components	13	25	12	15	14	2
19. Use of Printed Wiring	12	25	19	16	7	3
20. Use of Special Electronic Devices (e.g., Klystron)	8	12	9	21	18	11
21. Equipment Safety Hazards (e.g., Grounds Faulty)	7	18	13	15	17	10
22. Safety Devices-Inadequate (e.g., Not Enough Interlocks)	7	31	16	14	6	6
23. Warning Devices-Inadequate (e.g., Not Enough Warning Devices for all Hazards)	8	32	16	13	7	5
24. Support Equipment-Insufficient	3	20	6	16	28	7
25. Support Equipment Reliability-Low	9	25	11	16	16	2
26. Support Equipment Maintainability-Low	7	24	8	17	16	9
27. Modes of Operation-Too Few (e.g., Not Enough System Outputs for Mission)	10	37	14	5	8	3

GROUP II HARDWARE ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
28. Modes of Operation-Too Numerous (e.g., More System Outputs Available than Required for Mission; Hardware too Sophisticated)	8	35	16	15	5	1
29. Modes of Operation-Marginal (e.g., Under Ideal Conditions Just Enough Outputs Available for Mission)	11	24	10	14	13	13
30. Interfaces-Incorrect	7	30	3	9	12	20
31. Interfaces-Missing	10	37	5	9	6	9
32. Interfaces-Marginal	9	29	6	16	13	3
33. Maintainability-Low	7	11	9	23	26	6
34. Accessibility-Poor	7	24	10	11	26	3
35. Interchangeability-Poor	8	20	10	19	21	4
36. Localization-Difficult	7	19	8	24	17	6
37. Throw-away at Failure Maintenance Plan	13	41	12	7	7	1
38. Repair at Failure Maintenance Plan	12	3	16	26	13	11
39. Bench Repair Maintenance	8	2	20	26	19	5
40. Depot Repair Maintenance	9	8	13	18	23	7
41. Test Equipment-Insufficient	3	18	9	16	15	19
42. Test Equipment Reliability-Low	8	20	7	19	17	9

GROUP II HARDWARE ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
43. Test Equipment Maintainability-Low	4	26	8	12	21	9

GROUP III ENVIRONMENT ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Ambient Humidity-Low	12	3	16	10	1	1
2. Ambient Humidity-High	12	6	4	12	8	4
3. Ambient Temperature-Low	11	6	15	10	4	2
4. Ambient Temperature-High	10	29	4	8	11	8
5. Ambient Pressure-Low	13	28	11	8	1	0
6. Ambient Pressure-High	13	36	11	7	1	0
7. Shock-Excessive	9	24	5	11	8	4
8. Vibration-Excessive	9	25	5	10	9	4
9. Acceleration-High	12	46	11	3	6	1
10. Corrosion-Excessive	4	35	5	12	18	7
11. Radiation-Severe	10	41	6	9	8	5
12. Geographical Location (e.g., Europe)	3	12	14	15	32	5
13. Too Close to Storage Facilities	8	43	22	4	1	2
14. Too Far from Storage Facilities	8	22	14	15	17	3
15. Too Close to Transportation	8	42	25	3	1	1
16. Too Far from Transportation	5	18	16	18	19	2
17. Electro-magnetic Interference Level-High	11	17	11	16	14	10
18. Electro-magnetic Interference Level-Marginal	10	28	10	14	16	1

GROUP III ENVIRONMENT ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
19. Physical Terrain-Low Area	5	28	28	7	9	2
20. Physical Terrain-Mountainous Area	4	17	20	13	19	5
21. Too far From Support Facilities	2	8	12	26	26	5
22. Climatic Environment (e.g., Arctic)	3	9	13	25	25	6
23. Artificial Environment (e.g., Air Conditioning)	4	5	19	27	16	6
24. Proximity to Populated Areas	2	42	17	12	4	0
25. Embargo/Blockade	8	49	12	3	2	5
26. Air Space Restrictions	9	34	17	14	4	1
27. Proximity to Hostile Areas	6	46	18	2	4	4
28. Proximity to Unfriendly Areas	6	46	17	3	4	4
29. Enemy Countermeasures	9	29	15	13	4	8
30. Use of Indigenous Technical Personnel	4	42	14	8	8	3
31. Use of Indigenous Support Personnel	5	19	15	23	6	2

GROUP IV SUPPORT FACILITIES ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Prime Power Source-High Interruption Rate	5	22	9	12	8	22
2. Prime Power Source-Marginal Output	6	21	11	12	20	9
3. Prime Power Source-Low Reliability	5	22	6	13	16	17
4. Prime Power Source-Low Maintainability	10	28	9	6	16	10
5. Auxiliary Power Source-High Interruption Rate	10	31	8	5	15	10
6. Auxiliary Power Source-Marginal Output	10	30	8	5	19	7
7. Auxiliary Power Source-Low Reliability	11	30	8	5	16	9
8. Auxiliary Power Source-Low Maintainability	11	30	9	5	17	7
9. Real Estate-Too Small an Area	6	39	10	9	12	3
10. Real Estate-Too Large an Area	6	31	31	11	0	0
11. Real Estate-Physically Marginal	6	25	13	26	6	3
12. Real Estate-Site Acquisition Impossible (e.g., Impossible to Buy or Lease Real Estate)	8	49	10	1	3	8
13. Real Estate-Site Acquisition Delayed	6	47	8	3	6	8

GROUP IV SUPPORT FACILITIES ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
14. Buildings Containing System Hardware-Too Small	4	11	13	23	23	5
15. Buildings Containing System Hardware-Too Large	4	42	27	5	1	0
16. Buildings Containing System Hardware-Layout Inefficient	5	34	7	14	17	3
17. Buildings Containing System Hardware-Too Warm	7	23	8	23	12	5
18. Buildings Containing System Hardware-Too Cold	8	30	10	21	7	3
19. Buildings Containing System Hardware-Required Maintenance Excessive	12	20	15	13	17	2
20. Tower Height-Too Low (e.g., Radar Tower)	9	42	7	8	7	6
21. Tower Height-Too High	9	43	10	12	2	3
22. Tower-Electrical Maintenance Excessive	11	29	13	12	11	3
23. Tower-Mechanical Maintenance Excessive	11	23	11	10	21	3

GROUP V LOGISTICS ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Technical Operational Documents-Insufficient Supply	5	25	12	7	27	4
2. Technical Operational Documents-Supply Not on Time	4	25	10	8	24	9
3. Technical Operational Documents-Incorrect Documents Supplied	5	21	12	11	23	7
4. Technical Maintenance Documents-Insufficient Supply	6	23	15	13	21	2
5. Technical Maintenance Documents-Supply Not on Time	5	18	15	19	16	7
6. Technical Maintenance Documents-Incorrect Documents Supplied	7	21	6	12	23	7
7. Technical Support Documents-Insufficient Supply	10	24	14	13	18	1
8. Technical Support Documents-Supply Not on Time	8	24	12	13	17	6
9. Technical Support Documents-Incorrect Documents Supplied	7	28	11	6	24	4
10. Storage Facilities-Operation	9	27	17	17	11	1
11. Storage Facilities-Maintenance	11	19	20	17	11	—

GROUP V LOGISTICS ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
12. Storage Facilities-Support (Including Test)	10	16	25	12	14	3
13. Storage Environment-Operation	9	25	18	17	10	1
14. Storage Environment-Maintenance	11	20	23	15	10	1
15. Storage Environment-Support (Including Test)	11	19	23	14	11	2
16. Written Communications-Ineffective	5	17	14	23	16	4
17. Oral Communications-Ineffective	5	15	11	25	19	4
18. Other Communications-Ineffective (e.g., TWX, FAX)	6	16	13	21	17	5
19. Transportation-Elapsed Time Excessive	5	8	4	22	32	6
20. Transportation-Hardware Damaged Enroute	4	5	6	30	22	12
21. Inventory-Time Required Excessive	11	21	18	16	13	0
22. Inventory-Inaccurate or Incomplete	9	18	20	16	10	8
23. Turn Around Time-Item Failure to Item Replacement	4	6	5	24	20	16

GROUP VI PERSONNEL ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Operator-Training Level-Low	7	14	13	18	22	4
2. Operator-Skill Level-Low	7	11	18	17	18	6
3. Operator-Man-machine Interfaces-Incorrect	13	32	8	5	10	10
4. Operator-Man-machine Interfaces-Marginal	13	31	9	7	13	2
5. Operator-Number of Operators-Insufficient	9	26	10	13	19	4
6. Operator-Health-Marginal	11	35	12	10	6	3
7. Operator-Errors	10	14	6	20	19	9
8. Operator-Safety Hazards Numerous	11	28	6	18	12	3
9. Operator-Turn-over Rate-High	12	9	5	28	18	6
10. Operator-Ineffective Oral Communication	11	18	14	17	14	4
11. Operator-Ineffective Written Communication	12	17	23	11	13	2
12. Maintenance Personnel-Training Level-Low	4	17	7	24	20	7
13. Maintenance Personnel-Skill Level-Low	5	14	8	16	28	8
14. Maintenance Personnel-Man-machine Interfaces-incorrect	16	32	5	6	10	10
15. Maintenance Personnel-Man-machine Interfaces-Marginal	16	32	6	6	16	3

GROUP VI PERSONNEL ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
16. Maintenance Personnel-Number of Personnel-Insufficient	6	24	12	9	23	5
17. Maintenance Personnel-Health-Poor	14	33	10	11	10	1
18. Maintenance Personnel-Errors	8	7	9	27	17	10
19. Maintenance Personnel-Safety Hazards-Numerous	13	20	7	23	12	4
20. Maintenance Personnel-Turn-over Rate-High	11	11	5	33	14	5
21. Maintenance Personnel-Ineffective Oral Communication	11	21	9	21	15	2
22. Maintenance Personnel-Ineffective Written Communication	11	21	15	15	16	1
23. Logistics Personnel-Training Level-Inadequate	11	25	4	25	11	3
24. Logistics Personnel-Skill Level-Inadequate	12	19	8	24	13	3
25. Logistics Personnel-Man-machine Interfaces-Marginal	16	37	6	10	9	1
26. Logistics Personnel-Number of Personnel-Insufficient	11	37	3	14	11	3
27. Logistics Personnel-Health-Poor	13	37	7	16	5	1
28. Logistics Personnel-Errors	7	12	7	34	14	5

GROUP VI PERSONNEL ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
29. Logistics Personnel-Safety Hazards Numerous	12	38	7	14	4	3
30. Logistics Personnel-Turn-over Rate-High	12	21	8	28	6	3
31. Logistics Personnel-Ineffective Oral Communication	9	28	12	16	13	1
32. Logistics Personnel-Ineffective Written Communication	9	25	10	20	11	4
33. Personnel-Recreation Facilities-Inadequate	12	41	8	9	7	1
34. Personnel-Housing Facilities-Marginal	12	36	13	7	7	3
35. Personnel-Medical-Dental Facilities-Marginal	14	40	6	7	6	5

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Procedures-Operation-Ambiguous	10	22	12	13	17	6
2. Procedures-Operation-Incomplete	9	25	8	13	18	6
3. Procedures-Operation-Incorrect	9	26	8	11	15	11
4. Procedures-System Maintenance-Ambiguous	10	17	6	13	21	4
5. Procedures-System Maintenance-Incomplete	9	20	12	14	21	5
6. Procedures-System Maintenance-Incorrect	10	20	13	13	11	10
7. Procedures-Test-Ambiguous	8	22	11	17	17	7
8. Procedures-Test-Incomplete	6	25	7	15	20	4
9. Procedures-Test-Incorrect	7	25	6	14	12	10
10. Procedures-Requisition-Ambiguous	10	32	6	13	16	2
11. Procedures-Requisition-Incomplete	10	32	7	13	14	3
12. Procedures-Requisition-Incorrect	10	32	6	14	11	6
13. Procedures-Transportation-Ambiguous	11	36	9	15	8	2
14. Procedures-Transportation-Incomplete	11	36	9	12	10	5
15. Procedures-Transportation-Incorrect	11	36	9	12	7	5

GROUP V11 WRITTEN PROCEDURES ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
16. Procedures-Inventory Ambiguous	10	30	12	18	8	1
17. Procedures-Inventory-Incomplete	9	34	9	15	12	0
18. Procedures-Inventory-Incorrect	9	33	7	17	8	8
19. Procedures-Communication-Ambiguous	12	30	9	17	8	4
20. Procedures-Communication-Incomplete	12	30	10	14	9	5
21. Procedures-Communication-Incorrect	12	29	10	13	4	8
22. Procedures-Administrative-Ambiguous	13	25	11	9	7	4
23. Procedures-Administrative-Incomplete	13	29	8	15	7	6
24. Procedures-Administrative-Incorrect	13	30	8	12	6	9
25. Procedures-Safety-Ambiguous	12	33	8	13	7	5
26. Procedures-Safety-Incomplete	11	33	8	13	6	7
27. Procedures-Safety-Incorrect	11	34	6	11	8	8
28. Procedures-Countermeasures-Ambiguous	11	37	10	10	5	6
29. Procedures-Countermeasures-Incomplete	11	37	10	9	6	5

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
30. Procedures- Counter-measures-Incorrect	11	42	6	9	3	7
31. Procedures-Training-Ambiguous	9	29	12	16	7	7
32. Procedures-Training-Incomplete	9	28	12	16	7	8
33. Procedures-Training-Incorrect	9	28	13	13	7	10
34. Procedures-Storage-Ambiguous	11	30	17	17	4	2
35. Procedures-Storage-Incomplete	10	30	17	16	4	3
36. Procedures-Storage-Incorrect	11	30	16	11	6	5
37. Procedures-Facilities Maintenance-Ambiguous	13	30	14	13	7	1
38. Procedures-Facilities Maintenance-Incomplete	13	30	14	12	6	3
39. Procedures-Facilities Maintenance-Incorrect	13	30	14	10	5	7
40. Procedures-Overall Mission-Ambiguous	10	28	11	5	16	8
41. Procedures-Overall Mission-Incomplete	10	26	11	5	18	8
42. Procedures-Overall Mission-Incorrect	10	28	10	4	11	15
43. Procedures-Standard Operating Procedures-Ambiguous	11	24	11	16	11	5

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
44. Procedures-Standard Operating Procedures-Incomplete	10	21	13	15	14	5
45. Procedures-Standard Operating Procedures-Incorrect	10	21	12	12	11	11

GROUP VIII DOCUMENTATION ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Operation-Technical Manual-Difficult to Read	11	16	15	18	18	1
2. Operation-Technical Manual-Poorly Organized	11	16	15	23	14	0
3. Operation-Operational Logs-Difficult to read	11	25	13	16	13	0
4. Operation-Operational Logs-Poorly Organized	11	25	14	15	13	0
5. Operation-Time Logs-Difficult to Read	13	27	14	16	8	0
6. Operation-Time Logs-Poorly Organized	15	27	14	15	7	0
7. Maintenance-Technical Manuals-Difficult to Read	11	13	14	26	12	3
8. Maintenance-Technical Manuals-Poorly Organized	11	14	14	27	12	1
9. Maintenance-Maintenance Logs-Difficult to Read	14	21	13	20	11	0
10. Maintenance-Maintenance Logs-Poorly Organized	14	21	14	21	10	0
11. Failure Reporting Forms-Difficult to Read	9	14	13	33	10	0
12. Failure Reporting Forms-Poorly Organized	9	28	12	21	8	1
13. Training-Manuals-Difficult to Read	11	28	16	14	9	1
14. Training-Manuals-Poorly Organized	11	28	15	15	10	0

GROUP VIII DOCUMENTATION ORIENTED FACTORS (Continued)

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
15. Administrative Forms-Difficult to Read	8	29	15	21	5	0
16. Administrative Forms-Poorly Organized	9	29	13	25	3	0
17. Safety-Manuals-Difficult to Read	10	29	18	9	9	2
18. Safety-Manuals-Poorly Organized	10	29	18	10	9	1
19. Logistics-Technical Manuals-Difficult to read	8	32	13	16	10	0
20. Logistics-Technical Manuals-Poorly Organized	8	32	15	16	8	0

GROUP IX ADMINISTRATIVE-MANAGEMENT ORIENTED FACTORS

Specific Factors	No Knowledge of this Factor	Factor Not Applicable	Adverse Effect of Each Factor			
			None	Minimal	Significant	Critical
1. Administrative Capability-Inadequate	6	29	11	12	16	4
2. Administrative Delays-Excessive	7	21	7	19	17	7
3. Administrative Organization-Weak	8	27	10	11	18	4
4. Administrative Reports-Incomplete	8	28	13	16	11	2
5. Administrative Control-Weak	8	27	13	9	17	4
6. Administrative Planning-Ineffective	7	27	10	10	15	9
7. Administrative Scheduling-Weak	7	27	10	13	15	6
8. Administrative Services-Marginal	9	27	15	11	15	1
9. Administrative Coordination-Ineffective	7	28	11	11	15	6

GROUP X ADDITIONAL FACTORS

Specific Factors	Adverse Effect of Each Factor		
	Minimal	Significant	Critical

APPENDIX II

Results of Rank Order Analysis of Systems Effectiveness Survey

GROUP I MISSION ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Mission Tolerances - Narrow	S	M	S	S
2.	Mission Tolerances - Broad	M	N	S	M
3.	Mission Recovery Time - Short	S	N	S	N
4.	Mission Recovery Time - Long	N	N	S	N
5.	Mission Accuracy - Low	M	N	S	M
6.	Mission Accuracy - High	M	N	S	S
7.	Mission Frequency - Low	M	N	S	M
8.	Mission Frequency - High	S	M	S	M
9.	Mission Repeatability - Low	M	N	S	M
10.	Mission Repeatability - High	M	N	S	M
11.	Mission Highly Specialized	M	N	S	S
12.	Mission Routine	N	N	S	M
13.	Mission Goals - Numerous	N	N	S	M
14.	Mission Goals - Not Clearly Defined	N	N	S	S

GROUP I MISSION ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
15.	Mission Goals - Ambiguous	N	N	S	S
16.	Mission Length - Long	S	S	S	S
17.	Mission Length - Short	M	N	M	M

GROUP II HARDWARE ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Reliability - Low	S	N	S	S
2.	No Redundancy or Backup	S	N	S	S
3.	Redundancy or Back-up Insufficient	S	N	S	S
4.	Electrical Stress - High (e.g., Part or Circuit Stress)	S	N	N	M
5.	Mechanical St[illegible] - High	S	N	N	M
6.	System Thermal Stress - High Temperature	M	N	N	M
7.	System Thermal Stress - Low Temperature	M	N	N	M
8.	Use of Non-Standard Parts	S	M	N	M
9.	Use of Microelectronic Devices	N	N	N	M
10.	System Electrical Tolerances - Narrow (e.g., Radar Power Output 1 KW 5%)	S	S	N	S
11.	System Electrical Tolerances - Broad (e.g., Radar Power Output 1 KW 20%)	N	N	M	M

GROUP II HARDWARE ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
12.	System Mechanical Tolerances – Narrow (e.g., Mechanical Clearance .005 in.)	M	N	N	M
13.	System Mechanical Tolerances – Broad (e.g., Mechanical Clearance .250 in.)	N	N	N	M
14.	Shock – Severe	N	N	N	M
15.	Vibration – Severe	N	N	N	M
16.	Use of Encapsulated Parts, Assemblies, Components	M	N	M	M
17.	Use of Embedded Parts, Assemblies, Components	M	N	M	M
18.	Use of Potted Parts, Assemblies, Components	M	N	M	M
19.	Use of Printed Wiring	M	N	S	M
20.	Use of Special Electronic Devices (e.g., Klystron)	M	M	N	S
21.	Equipment Safety Hazards (e.g., Grounds Faulty)	M	N	M	M
22.	Safety Devices Inadequate (e.g., Not Enough Interlocks)	N	N	M	M

GROUP II HARDWARE ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
23.	Warning Devices - Inadequate (e.g., Not Enough Warning Devices for all Hazards)	N	N	S	M
24.	Support Equipment - Insufficient	M	S	S	S
25.	Support Equipment - Reliability - Low	M	N	S	S
26.	Support Equipment - Maintainability - Low	M	N	S	M
27.	Modes of Operation - Too Few (e.g., Not Enough System Outputs for Mission)	M	N	M	M
28.	Modes of Operation - Too Numerous (e.g., More System Outputs Available than required for Mission; Hardware too Sophisticated)	M	N	S	M
29.	Modes of Operation - Marginal (e.g., Under Ideal Conditions Just Enough Outputs Available for Mission)	M	N	S	M
30.	Interfaces - Incorrect	S	N	S	S
31.	Interfaces - Missing	N	N	S	S
32.	Interfaces - Marginal	M	N	S	S
33.	Maintainability - Low	S	M	S	M

GROUP II HARDWARE ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
34.	Accessibility - Poor	N	N	S	S
35.	Interchangeability - Poor	M	N	S	S
36.	Localization - Difficult	M	N	S	S
37.	Throw-away at Failure Maintenance Plan	N	N	N	M
38.	Repair at Failure Maintenance Plan	M	M	N	M
39.	Bench Repair Maintenance	M	M	M	S
40.	Depot Repair Maintenance	S	M	N	M
41.	Test Equipment - Insufficient	M	S	M	S
42.	Test Equipment Reliability - Low	S	N	S	S
43.	Test Equipment Maintainability - Low	N	N	S	S

GROUP III ENVIRONMENTAL ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Ambient Humidity - Low	M	M	N	M
2.	Ambient Humidity - High	N	N	M	S
3.	Ambient Temperature - Low	M	M	M	M
4.	Ambient Temperature - High	N	N	S	S
5.	Ambient Pressure - Low	N	N	N	M
6.	Ambient Pressure - High	N	N	N	M
7.	Shock - Excessive	N	N	M	M
8.	Vibration - Excessive	N	N	M	S
9.	Acceleration - High	N	N	M	N
10.	Corrosion - Excessive	S	N	M	S
11.	Radiation - Severe	M	N	M	M
12.	Geographical Location (e.g., Europe)	N	S	M	M
13.	Too Close to Storage Facilities	N	N	M	M
14.	Too Far from Storage Facilities	N	N	M	M
15.	Too Close to Transportation	N	N	M	M
16.	Too Far from Transportation	N	M	M	M

GROUP III ENVIRONMENTAL ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
17.	Electromagnetic Interference Level - High	M	N	M	S
18.	Electromagnetic Interference Level - Marginal	N	N	M	S
19.	Physical Terrain - Low Area	M	N	M	M
20.	Physical Terrain - Mountainous Area	M	S	M	M
21.	Too Far from Support Facilities	S	M	N	M
22.	Climatic Environment (e.g., Arctic)	M	M	M	M
23.	Artificial Environment (e.g., Air Conditioning)	M	M	S	S
24.	Proximity to Populated Areas	N	N	M	M
25.	Embargo/Blockade	N	N	M	N
26.	Air Space Restrictions	N	N	M	M
27.	Proximity to Hostile Areas	N	N	M	M
28.	Proximity to Unfriendly Areas	N	N	M	M
29.	Enemy Countermeasures	N	N	M	N

GROUP III ENVIRONMENTAL ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
30.	Use of Indigenous Technical Personnel	N	N	M	M
31.	Use of Indigenous Support Personnel	M	M	M	M

GROUP IV SUPPORT FACILITIES ORIENTED I CTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Prime Power Source - High Interruption Rate	M	N	S	S
2.	Prime Power Source - Marginal Output	M	N	S	S
3.	Prime Power Source - Low Reliability	N	N	S	S
4.	Prime Power Source - Low Maintainability	N	N	S	S
5.	Auxiliary Power Source - High Interruption Rate	N	N	S	S
6.	Auxiliary Power Source - Marginal Output	N	N	S	S
7.	Auxiliary Power Source - Low Reliability	N	N	S	S
8.	Auxiliary Power Source - Low Maintainability	N	N	S	S
9.	Real Estate - Too Small an Area	N	N	M	M
10.	Real Estate - Too Large an Area	N	N	N	M
11.	Real Estate - Physically Marginal	M	N	N	M
12.	Real Estate - Site Acquisition Impossible (e.g., Impossible to Buy or Lease Real Estate)	N	N	N	N

GROUP IV SUPPORT FACILITIES ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
13.	Real Estate - Site Acquisition Delayed	N	N	N	N
14.	Buildings Containing System Hardware - Too Small	S	S	M	M
15.	Buildings Containing System Hardware - Too Large	N	N	N	M
16.	Buildings Containing System Hardware - Layout Inefficient	M	N	S	M
17.	Buildings Containing System Hardware - Too Warm	M	N	N	S
18.	Buildings Containing System Hardware - Too Cold	N	N	N	M
19.	Buildings Containing System Hardware - Required Maintenance Excessive	M	N	N	M
20.	Tower Height - Too Low (e.g., Radar Tower)	N	N	N	M
21.	Tower Height - Too High	N	N	N	M
22.	Tower - Electrical Maintenance Excessive	N	N	N	M
23.	Tower - Mechanical Maintenance Excessive	S	N	N	M

GROUP V LOGISTICS ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Technical Operational Documents - Insufficient Supply	S	N	S	S
2.	Technical Operational Documents - Supply Not on Time	S	N	M	S
3.	Technical Operational Documents- Incorrect Documents Supplied	S	N	S	S
4.	Technical Maintenance Documents-Insufficient Supply	S	M	S	S
5.	Technical Maintenance Documents - Supply Not on Time	S	M	S	S
6.	Technical Maintenance Documents - Incorrect Documents Supplied	S	N	S	S
7.	Technical Support Documents-Insufficient Supply	N	N	S	S
8.	Technical Support Documents - Supply Not on Time	M	N	S	S
9.	Technical Support Documents-Incorrect Documents Supplied	N	N	S	S
10.	Storage Facilities - Operation	M	N	M	M

GROUP V LOGISTICS ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
11.	Storage Facilities - Maintenance	M	M	N	M
12.	Storage Facilities - Support (Including Test)	M	M	N	M
13.	Storage Environment - Operation	M	N	M	M
14.	Storage Environment - Maintenance	N	M	N	M
15.	Storage Environment - Support (Including Test)	M	M	N	M
16.	Written Communications - Ineffective	M	M	M	S
17.	Oral Communications - Ineffective	M	M	M	S
18.	Other Communications - Ineffective (e.g., TWX, FAX)	M	M	M	S
19.	Transportation - Elapsed Time Excessive	S	S	N	S
20.	Transportation - Hardware Damaged Enroute	S	M	N	S
21.	Inventory - Time Required Excessive	M	N	N	M
22.	Inventory - Inaccurate or Incomplete	M	M	N	S

GROUP V LOGISTICS ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
23.	Turn Around Time – Item Failure to Item Replacement	M	S	N	S

GROUP VI PERSONNEL ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Operator – Training Level – Low	S	M	S	S
2.	Operator – Skill Level – Low	S	M	S	S
3.	Operator – Man-machine Interfaces – Incorrect	S	N	S	S
4.	Operator – Man-machine Interfaces – Marginal	M	N	M	S
5.	Operator – Number of Operators – Insufficient	S	N	M	S
6.	Operator – Health – Marginal	N	N	M	M
7.	Operator – Errors	S	N	S	S
8.	Operator – Safety Hazards Numerous	M	N	M	S
9.	Operator – Turn-over Rate – High	M	M	M	S
10.	Operator – Ineffective Oral Communication	M	N	M	S
11.	Operator – Ineffective Written Communication	M	N	S	S
12.	Maintenance Personnel – Training Level – Low	S	M	S	S
13.	Maintenance Personnel – Skill Level – Low	S	S	S	S

GROUP VI PERSONNEL ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
14.	Maintenance Personnel-Man-machine Interfaces - Incorrect	S	N	S	S
15.	Maintenance Personnel-Man-machine Interfaces - Marginal	N	N	S	S
16.	Maintenance Personnel-Number of Personnel - Insufficient	N	N	S	S
17.	Maintenance Personnel-Health - Poor	N	N	M	M
18.	Maintenance Personnel-Errors	M	M	S	S
19.	Maintenance Personnel-Safety Hazards - Numerous	M	N	M	S
20.	Maintenance Personnel-Turn-over Rate-High	M	M	M	S
21.	Maintenance Personnel-Ineffective Oral Communication	M	N	M	S
22.	Maintenance Personnel-Ineffective Written Communication	M	N	S	S
23.	Logistics Personnel-Training Level - Inadequate	M	N	N	S
24.	Logistics Personnel - Skill Level - Inadequate	M	M	N	M

GROUP VI PERSONNEL ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
25.	Logistics Personnel - Man-machine Interfaces - Marginal	N	N	N	M
26.	Logistics Personnel - Number of Personnel - Insufficient	N	N	N	M
27.	Logistics Personnel - Health - Poor	N	N	N	M
28.	Logistics Personnel - Errors	M	M	M	S
29.	Logistics Personnel - Safety Hazards Numerous	N	N	N	M
30.	Logistics Personnel - Turn-over Rate - High	N	M	N	M
31.	Logistics Personnel - Ineffective Oral Communication	N	N	N	M
32.	Logistics Personnel - Ineffective Written Communication	N	N	N	M
33.	Personnel-Recreation Facilities-Inadequate	N	N	N	M
34.	Personnel-Housing Facilities - Marginal	N	N	N	N
35.	Personnel - Medical - Dental Facilities - Marginal	N	N	N	M

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Procedures - Operation-Ambiguous	M	N	M	S
2.	Procedures - Operation-Incomplete	M	N	S	S
3.	Procedures-Operation-Incorrect	M	N	S	S
4.	Procedures - System Maintenance-Ambiguous	S	N	S	S
5.	Procedures - System Maintenance - Incomplete	S	N	S	S
6.	Procedures - System Maintenance - Incorrect	S	N	S	S
7.	Procedures - Test - Ambiguous	S	N	M	S
8.	Procedures - Test - Incomplete	M	N	M	S
9.	Procedures - Test - Incorrect	S	N	S	S
10.	Procedures - Requisition - Ambiguous	M	N	N	S
11.	Procedures - Requisition - Incomplete	M	N	N	M
12.	Procedures - Requisition - Incorrect	M	N	N	S

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
13.	Procedures - Transportation - Ambiguous	N	N	N	M
14.	Procedures - Transportation - Incomplete	N	N	N	M
15.	Procedures - Transportation - Incorrect	N	N	N	M
16.	Procedures - Inventory-Ambiguous	N	N	M	M
17.	Procedures - Inventory-Incomplete	N	N	M	M
18.	Procedures - Inventory-Incorrect	N	N	M	M
19.	Procedures - Communication - Ambiguous	M	N	M	M
20.	Procedures - Communication - Incomplete	N	N	M	M
21.	Procedures - Communication - Incorrect	N	N	M	M
22.	Procedures - Administrative - Ambiguous	M	N	S	M
23.	Procedures - Administrative - Incomplete	M	N	S	M
24.	Procedures - Administrative - Incorrect	M	N	S	M
25.	Procedures - Safety - Ambiguous	N	N	M	M

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
26.	Procedures - Safety - Incomplete	N	N	M	M
27.	Procedures - Safety - Incorrect	N	N	M	M
28.	Procedures - Counter-measures-Ambiguous	N	N	M	N
29.	Procedures - Counter-measures - Incomplete	N	N	M	N
30.	Procedures - Counter-measures - Incorrect	N	N	N	N
31.	Procedures - Training-Ambiguous	M	N	S	M
32.	Procedures - Training-Incomplete	M	N	S	M
33.	Procedures - Training-Incorrect	M	N	S	S
34.	Procedures - Storage-Ambiguous	M	N	M	M
35.	Procedures - Storage-Incomplete	M	N	M	M
36.	Procedures - Storage-Incorrect	M	N	M	M
37.	Procedures - Facilities Maintenance-Ambiguous	N	N	N	M
38.	Procedures - Facilities Maintenance-Incomplete	N	N	N	M

GROUP VII WRITTEN PROCEDURES ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
39.	Procedures - Facilities Maintenance-Incorrect	N	N	N	N
40.	Procedures - Overall Mission - Ambiguous	S	N	N	S
41.	Procedures - Overall Mission - Incomplete	S	N	S	S
42.	Procedures - Overall Mission - Incorrect	S	N	N	S
43.	Procedures - Standard Operating Procedures - Ambiguous	S	N	M	S
44.	Procedures - Standard Operating Procedures - Incomplete	S	N	M	S
45.	Procedures - Standard Operating Procedures - Incorrect	S	N	S	S

GROUP VIII DOCUMENTATION ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Operation-Technical Manual-Difficult to Read	M	N	S	M
2.	Operation-Technical Manual- Poorly Organized	M	N	S	M
3.	Operation-Operational Logs -Difficult to Read	M	N	M	M
4.	Operation-Operational Logs-Poorly Organized	M	N	M	M
5.	Operation-Time Logs - Difficult to Read	M	N	M	M
6.	Operation-Time Logs - Poorly Organized	M	N	M	M
7.	Maintenance-Technical Manuals - Difficult to Read	M	N	S	M
8.	Maintenance-Technical Manuals - Poorly Organized	M	N	S	M
9.	Maintenance-Maintenance Logs - Difficult to Read	M	N	S	M
10.	Maintenance-Maintenance Logs - Poorly Organized	M	N	S	M
11.	Failure Reporting Forms-Difficult to Read	M	M	M	M

GROUP VIII DOCUMENTATION ORIENTED FACTORS (Continued)

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
12.	Failure Reporting Forms-Poorly Organized	M	N	M	M
13.	Training-Manuals - Difficult to Read	M	N	M	M
14.	Training - Manuals-Poorly Organized	M	N	M	M
15.	Administrative Forms-Difficult to Read	M	N	M	M
16.	Administrative Forms-Poorly Organized	M	N	M	M
17.	Safety - Manuals - Difficult to Read	M	N	M	M
18.	Safety - Manuals - Poorly Organized	M	N	M	M
19.	Logistics - Technical Manuals - Difficult to Read	M	N	M	M
20.	Logistics - Technical Manuals - Poorly Organized	M	N	M	M

GROUP IX ADMINISTRATIVE - MANAGEMENT ORIENTED FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Administrative Capability-Inadequate	M	N	S	M
2.	Administrative Delays-Excessive	M	N	S	S
3.	Administrative Organization - Weak	M	N	S	S
4.	Administrative Reports-Incomplete	M	N	M	M
5.	Administrative Control-Weak	M	N	S	S
6.	Administrative Planning-Ineffective	M	N	S	S
7.	Administrative Scheduling - Weak	M	N	S	S
8.	Administrative Services-Marginal	M	N	M	M
9.	Administrative Coordination - Ineffective	M	N	S	S

GROUP X ADDITIONAL FACTORS

	Specific Factors	Radar Subsystems	Communication Subsystems	Computer Subsystems	Missile Support Subsystems
1.	Operations Problems	-	S	-	-
2.	Customer Directions Slow or Non-existent	-	S	-	-
3.	Equipment Delivery Schedule Inaccurate	-	S	-	-
4.	Incremental Funding Delays or Holds	-	S	-	-
5.	Site Clearance Delays	-	S	-	-

APPENDIX III

Relationship of Constituent Abilities and Related Factors
to Functional Activities

CONTENTS

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(Con'td.)

CONTENTS
(Con'td.)

CONTENTS
(Con'td.)

FIGURE NO. PAGE

SYSTEMS ANALYSIS/
SYSTEMS ENGINEERING
(Con'td.)

LOGISTICS/SUPPORT

CONTENTS
(Con'td.)

CONTENTS
(Con'td.)

CONTENTS
(Con'td.)

CONTENTS
(Con'td.)

CONTENTS
(Con'td.)

CONTENTS
(Con'td.)

PROGRAM MANAGEMENT FUNCTION

ADMINISTRATION/ SCHEDULING/ PLANNING

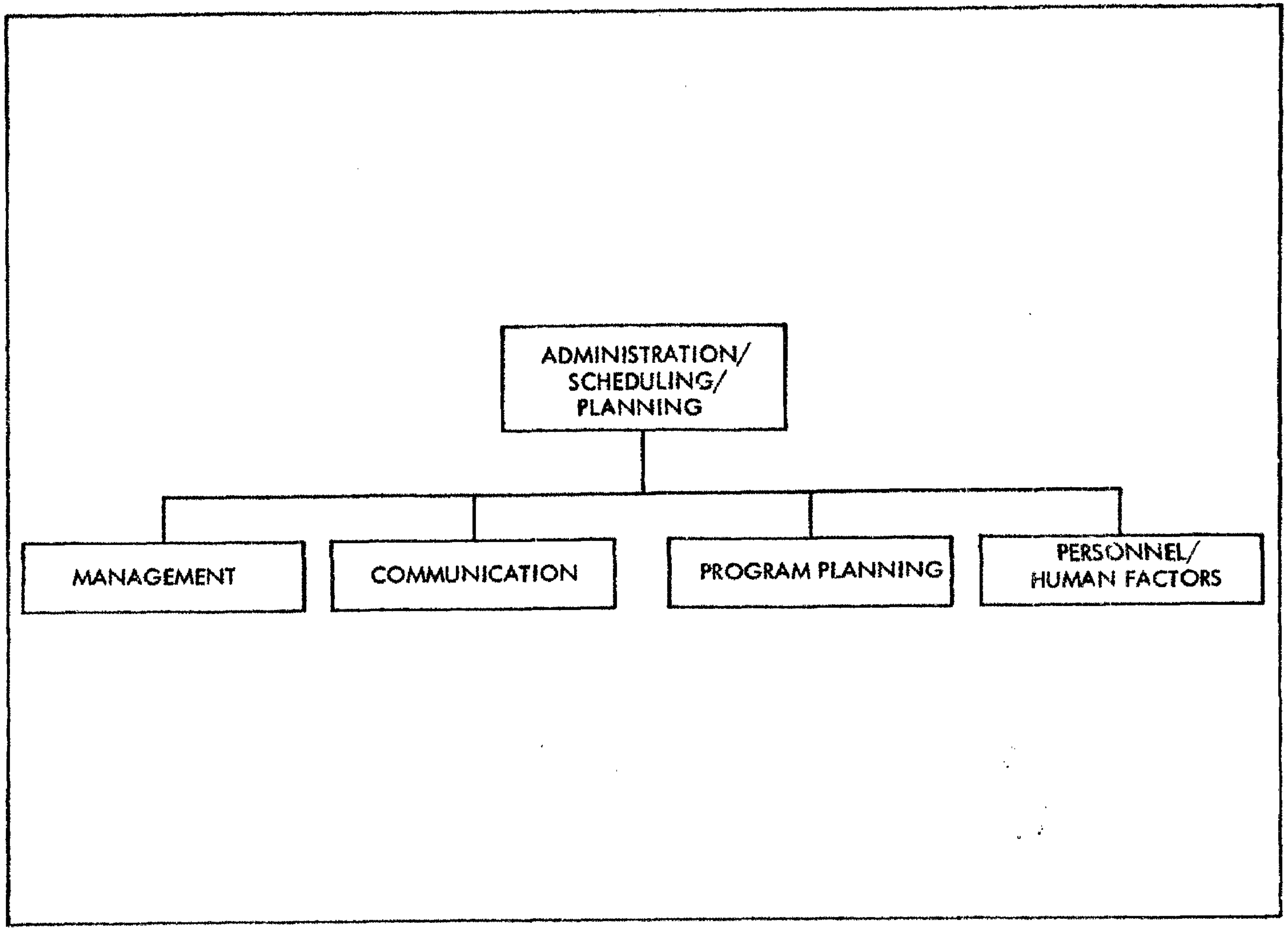

Figure 8. Constituent Abilities Relating to Administration/Scheduling/Planning

MANAGEMENT

SUBABILITIES

ANALYZE

	PRIORITY PHASE 1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	1
ADMINISTRATIVE Organization Control Planning Scheduling Coordination Procedures Capability	2	2	2	2
OPERATIONAL REQUIREMENTS	3	3	3	3
TECHNICAL CAPABILITY	4	4	4	4
MAINTAIN				
DESIGN INTEGRITY	-	-	5	-
EVALUATE				
MANAGEMENT QUALIFICATIONS	5	5	6	5
CONTRACT MANAGEMENT	6	6	7	6
MATERIEL MANAGEMENT	-	7	8	7

Figure 9.
Management Subabilities and Related Factors Associated With Administration/Scheduling/Planning
(Sheet 1 of 3)

	PRIORITY			
	PHASE			
	1	2	3	4
SECURITY REQUIREMENTS	7	8	9	8
DISCREPANCIES	-	9	10	9
CONSIDER				
GOVERNMENT MANAGEMENT PERSONNEL	8	10	11	10
GOVERNMENT OPERATIONS PERSONNEL	9	11	12	11
ISOLATE				
PROBLEM AREAS	10	12	13	12
INITIATE				
CORRECTIVE ACTION	11	13	14	13
CONFIGURATION MANAGEMENT	-	14	15	14

Figure 9

Continued. (Sheet 2 of 3)

RELATED FACTORS

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
ADMINISTRATIVE DELAYS	-	1	1	1
REPORTS/DATA	-	2	2	2
MANAGEMENT TECHNIQUES DEVELOPMENT	1	3	-	-

Figure 9

Continued. Sheet 3 of 3)

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
PROCEDURES Overall Mission Operating	-	-	1	-
EVALUATE				
GOVERNMENT - CONTRACTOR COMMUNICATION	-	1	2	-
WRITTEN COMMUNICATIONS	1	2	3	-
ORAL COMMUNICATIONS	2	3	4	-

Figure 10
Communication Subabilities Associated With Administration/
Scheduling/Planning
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
DEFINE				
MISSION ELEMENTS	1	1	1	-
TIME PHASING	2	2	2	-
MILESTONES	3	3	3	-
TASK DESCRIPTION	4	4	4	-
ANALYZE				
PLANNING PROCEDURES	5	5	5	-
ESTABLISH				
GOALS	6	6	6	-
REQUIREMENTS	7	7	7	-
CONSTRAINTS	8	8	8	-
TRADE-OFFS	-	9	9	-
MANUFACTURING SUPPORT	-	10	10	-
FIELD SUPPORT	-	11	11	-

Figure 11

Program Planning Subabilities and Related Factors Associated With Administration/Scheduling/Planning

(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
IMPLEMENT				
CORRECTIVE ACTION	9	12	12	-
RELATED FACTORS				
ASSIGN				
RESPONSIBILITY FOR TASK ACCOMPLISHMENT	1	1	1	-
ANALYZE				
REPORTS/DATA	-	2	2	-
DATA FEEDBACK	-	-	3	-

Figure 11

Continued. (Sheet 2 of 2)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
ANALYZE				
PERSONNEL REQUIREMENTS	1	1	1	-
TYPE OF PERSONNEL				
Administrative	2	2	2	-
Operations	3	3	3	-
Logistics	4	4	4	-
Maintenance	5	5	5	-
Engineering	6	6	6	-
NUMBER OF PERSONNEL	7	7	7	-
TURN-OVER RATE	8	8	8	-
CONSIDER				
NEW PERSONNEL	9	9	9	-
HEALTH	10	10	10	-

Figure 12

Personnel/Human Factor Subabilities and Related Factors Associated With Administration/Scheduling/Planning (Sheet 1 of 2)

RELATED FACTORS	PRIORITY PHASE 1	2	3	4
ANALYZE				
PERSONNEL DEVELOPMENT	-	1	1	-
PERSONNEL ADAPTATION	-	2	2	-
EXTENDED WORK SCHEDULES	-	3	3	-
EVALUATE				
PERSONNEL SELECTION	-	4	4	-

Figure 12
Continued. (Sheet 2 of 2)

CONTRACT ADMINISTRATION

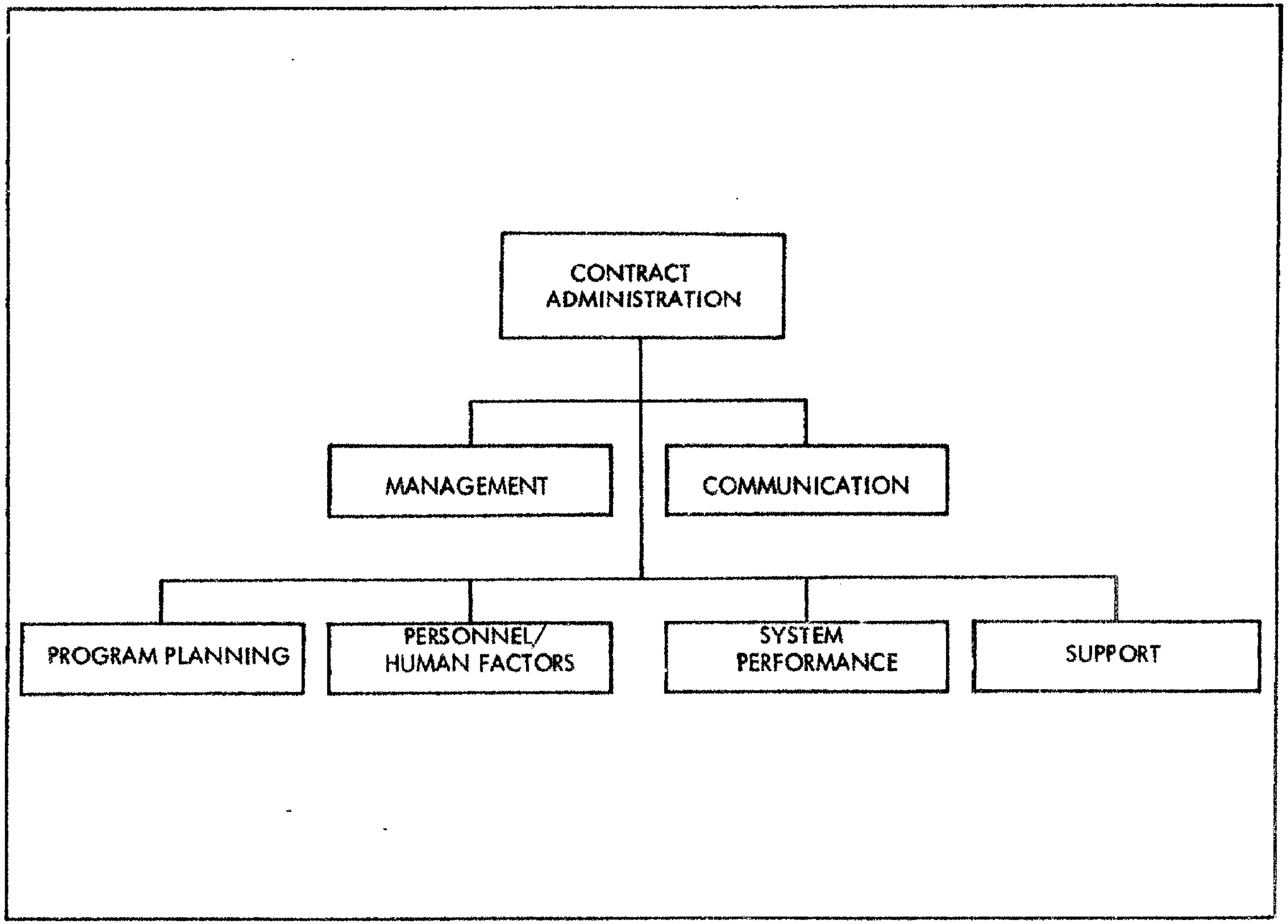

Figure 13. Constituent Abilities Relating to Contract Administration

MANAGEMENT

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
ADMINISTRATION Organization Scheduling Control Coordination Planning Capability Procedures	1	1	1	-
EVALUATE				
CONTRACT MANAGEMENT	2	2	2	-
TECHNICAL CAPABILITY	3	3	3	-
MATERIEL MANAGEMENT	4	4	4	-
CONSIDER				
GOVERNMENT MANAGEMENT PERSONNEL	5	5	5	1
INITIATE				
CORRECTIVE ACTION	6	6	6	2

Figure 14
Management Subabilities and Related Factors Associated With Contract Administration
(Sheet 1 of 2)

RELATED FACTORS

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
ADMINISTRATIVE DELAYS	-	1	1	1
REPORTS/DATA	-	2	2	2

Figure 14

Continued. (Sheet 2 of 2)

COMMUNICATION

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
GOVERNMENT-CONTRACTOR COMMUNICATION	1	1	1	1
GOVERNMENT STANDARDS, PROCEDURES & FORMATS	2	2	2	2
WRITTEN COMMUNICATIONS	3	3	3	3
ORAL COMMUNICATIONS	4	4	4	4

Figure 15

Communication Subabilities Associated With Contract Administration

(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
PLANNING PROCEDURES	1	1	1	-
TASK DESCRIPTION	2	2	2	-
TIME PHASING	-	3	3	-
MILESTONES	3	4	4	-
GOALS	4	5	5	-
REQUIREMENTS	5	6	6	-
CONSTRAINTS	6	7	7	-
RELATED FACTORS				
EVALUATE				
REPORTS/DATA	1	1	1	1

Figure 16

Program Planning Subabilities and Related Factors Associated With Contract Administration

(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
TYPE OF PERSONNEL	1	1	1	-
TURN-OVER RATE	2	2	2	-
NUMBER OF PERSONNEL	3	3	3	-
RELATED FACTORS				
ANALYZE				
GOVERNMENT - CONTRACTOR RELATIONS	1	1	1	1

Figure 17
Personnel/Human Factors Subabilities and Related Factors Associated
With Contract Administration
(Sheet 1 of 1)

SYSTEM PERFORMANCE	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
MISSION GOALS	1	1	1	-
ANALYZE				
SYSTEM MODIFICATIONS	-	2	2	1
RELATED FACTORS				
DETERMINE				
COST INFORMATION	-	1	1	1
EVALUATE				
PRODUCTION	-	2	2	-
PURCHASING	-	-	3	-

Figure 18
System Performance Subabilities and Related Factors Associated With Contract Administration
(Sheet 1 of 1)

SUPPORT

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	-

RELATED FACTORS

EVALUATE/ ACQUIRE

	PRIORITY			
	PHASE			
	1	2	3	4
SITE REAL ESTATE	1	1	1	-

Figure 19
Support Subabilities and Related Factors Associated With Contract Administration
(Sheet 1 of 1)

MARKETING/PROCUREMENT

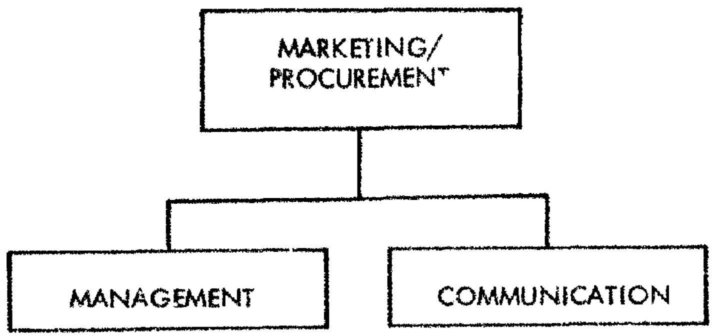

Figure 20. Constituent Abilities Relating to Marketing/Procurement

MANAGEMENT

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
ADMINISTRATIVE Organization Planning Scheduling Coordination Control Capability Procedures	1	1	-	-
TECHNICAL CAPABILITY	2	2	-	-
TECHNICAL INPUTS & OUTPUTS FROM ALL FUNCTIONAL ACTIVITIES (e.g., RELIABILITY/ MAINTAINABILITY)	3	3	-	-
CONSIDER				
GOVERNMENT MANAGEMENT PERSONNEL	4	4	-	-
EVALUATE				
CONTRACT MANAGEMENT	5	5	-	-
MATERIEL MANAGEMENT	6	6	-	-

Figure 21
Management Subabilities and Related Factors Associated With Marketing/Procurement
(Sheet 1 of 2)

RELATED FACTORS

ANALYZE

	PRIORITY PHASE 1	2	3	4
ADMINISTRATIVE DELAYS	1	1	-	-
MANAGEMENT TECHNIQUE DEVELOPMENT	-	2	1	-

Figure 21
Continued. (Sheet 2 of 2)

COMMUNICATION

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
GOVERNMENT STANDARDS, PROCEDURES & FORMATS	1	1	-	-
GOVERNMENT - CONTRACTOR COMMUNICATION	2	2	-	-
WRITTEN COMMUNICATIONS	3	3	-	-
ORAL COMMUNICATIONS	4	4	-	-

Figure 22

Communication Subabilities Associated With Marketing/Procurement (Sheet 1 of 1)

INDUSTRIAL RELATIONS

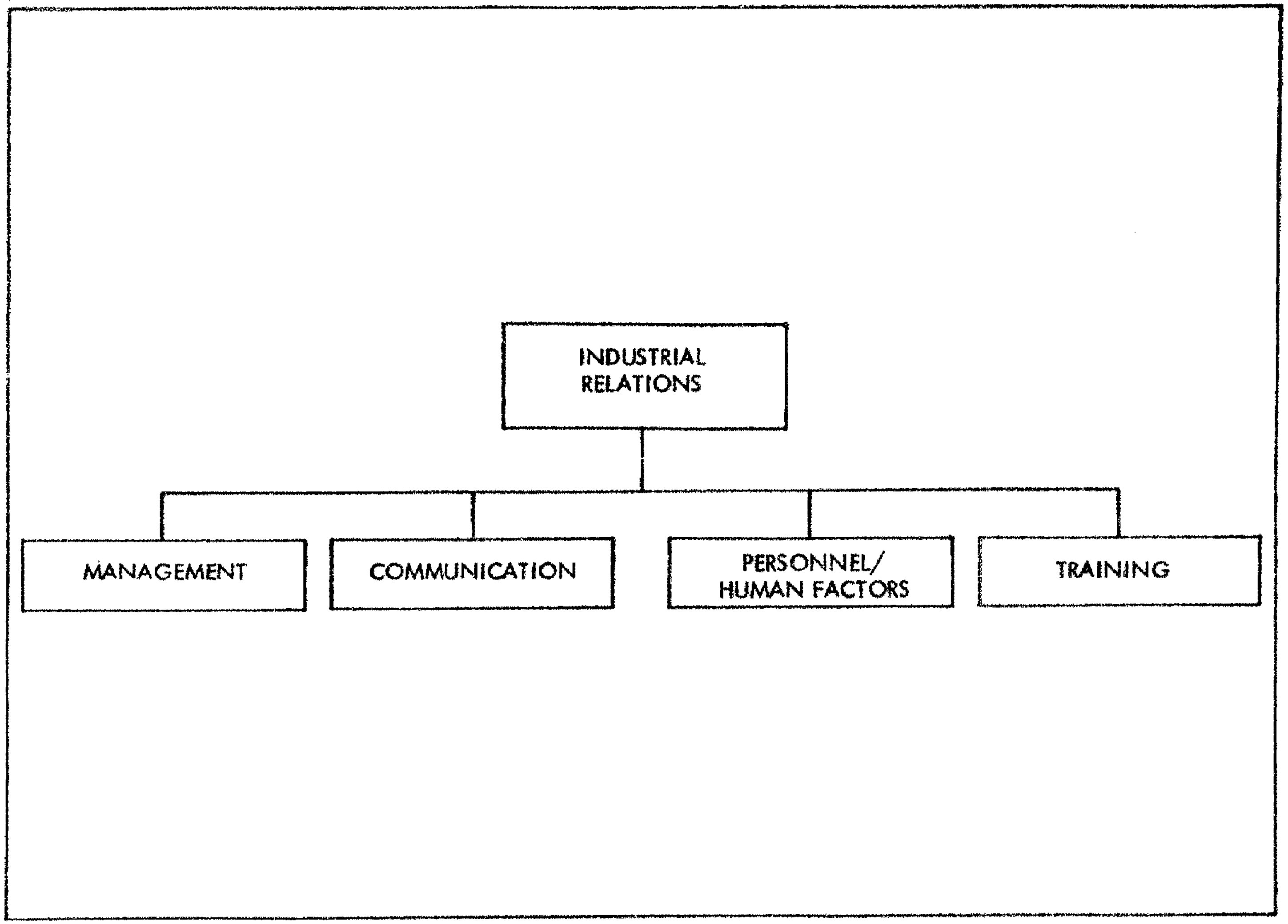

Figure 23. Constituent Abilities Relating to Industrial Relations

MANAGEMENT

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
ANALYZE				
ADMINISTRATIVE Organization Control Planning Coordination Capability Scheduling Procedures	1	1	1	-
TRAINING CAPABILITY	-	2	2	-
EVALUATE				
CONTRACT REQUIREMENTS	2	3	3	-
MANAGEMENT QUALIFICATIONS	3	4	4	-
IMPLEMENT				
SECURITY REQUIREMENTS	4	5	5	1

Figure 24.
Management Subabilities and Related Factors Associated With Industrial Relations
(Sheet 1 of 2)

RELATED FACTORS

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
MANAGEMENT - EMPLOYEE RELATIONSHIPS	-	1	1	1
ANALYZE				
MANAGEMENT TECHNIQUE DEVELOPMENT	-	2	2	-

Figure 24
Continued. (Sheet 2 of 2)

COMMUNICATION

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
GOVERNMENT STANDARDS, PROCEDURES & FORMATS	-	1	1	-
STANDARD OPERATING PROCEDURES	-	2	2	1
WRITTEN COMMUNICATIONS	1	3	3	2
ORAL COMMUNICATIONS	2	4	4	3

Figure 25
Communication Subabilities Associated With Industrial Relations
(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

ANALYZE

	PRIORITY PHASE 1	2	3	4
TYPE OF PERSONNEL LIST	-	-	1	-
PERSONNEL SELECTION	-	-	2	-
NUMBER OF PERSONNEL	-	-	3	1
TURN-OVER RATE	-	-	4	2
HUMAN ERROR	-	-	5	3

RELATED FACTORS

ANALYZE

	PRIORITY PHASE 1	2	3	4
PERSONNEL DEVELOPMENT	-	-	6	-
PERSONNEL ADAPTATION	-	-	7	4
EXTENDED WORK SCHEDULES	-	-	8	5
WORKING CONDITIONS	-	-	9	6

Figure 26
Personnel/Human Factors Subabilities and Related Factors Associated With Industrial Relations
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
CONSIDER				
HEALTH	-	-	10	7
MOTIVATION	-	-	11	8
EVALUATE				
HOUSING	-	-	12	-

Figure 26

Continued (Sheet 2 of 2)

TRAINING

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
EVALUATE				
TRAINING LEVEL	1	1	1	-
CURRICULA	-	-	2	-
INSTRUCTORS	-	-	3	-
MATERIAL	-	-	4	-
SPECIAL TRAINING DEVICES	-	-	5	-
SPECIALIZED EQUIPMENT TRAINING	-	-	6	-
CONTRACTOR TRAINING	-	-	7	-
ANALYZE				
PROCEDURES	-	2	8	-
DETERMINE				
NUMBER OF TRAINED PERSONNEL	2	3	9	-

Figure 27
Training Subabilities and Related Factors Associated With Industrial Relations
(Sheet 1 of 2)

RELATED FACTORS

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
CONCEPTS	1	1	1	-
TRAINING EQUIPMENT	-	-	2	-
FACILITIES	-	2	3	-
IMPLEMENT				
PLANS	-	3	4	-
PERSONNEL IMPROVEMENT PROGRAM	-	-	5	-

Figure 27
Continued. (Sheet 2 of 2)

OPERATIONS ANALYSIS

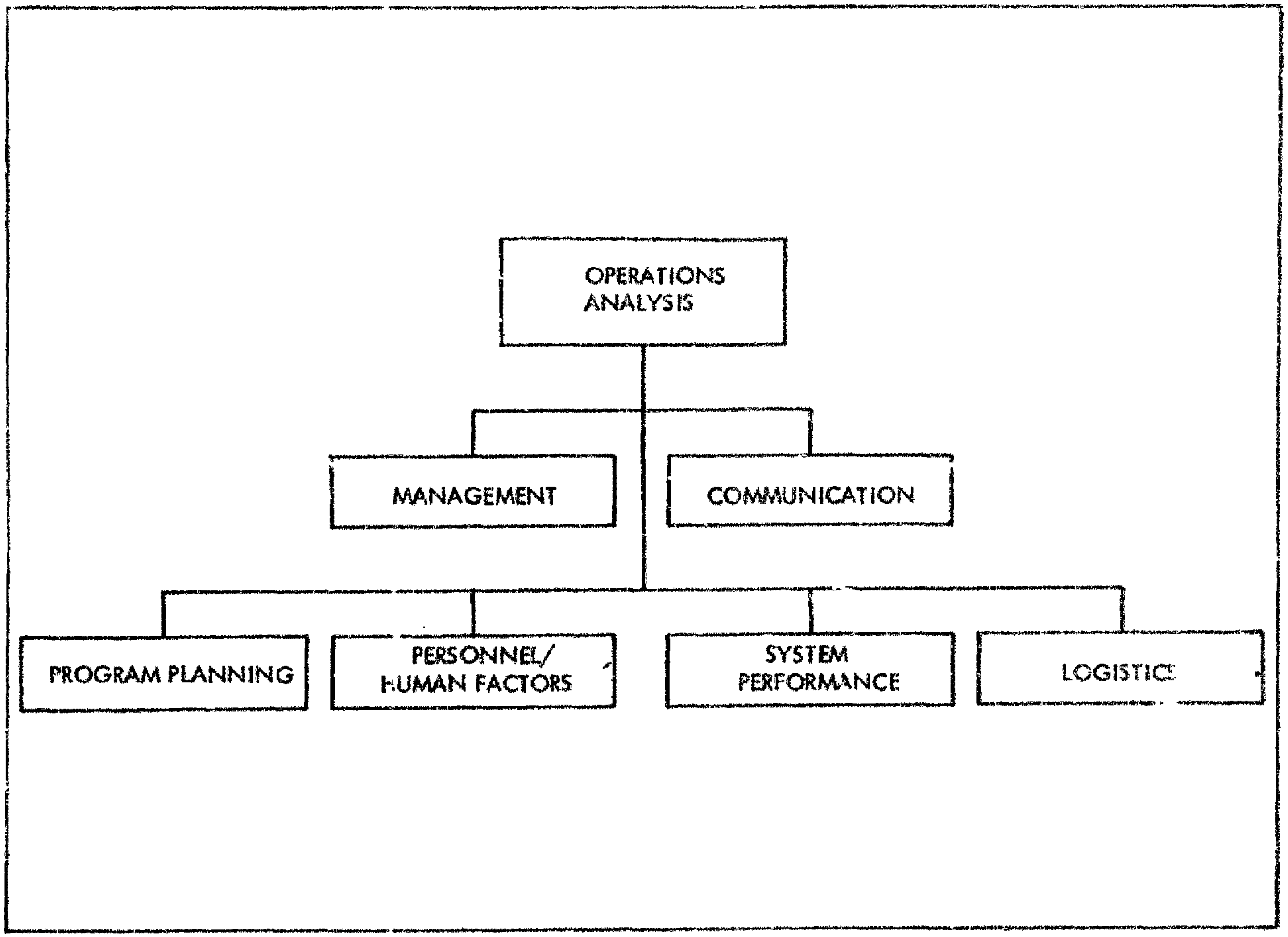

Figure 28. Constituent Abilities Relating to Operations Analysis

MANAGEMENT

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
OPTIMIZE				
ADMINISTRATIVE Organization Planning Scheduling Procedures Coordination	1	1	-	-
EVALUATE				
MANAGEMENT QUALIFICATIONS	2	-	-	-
CONTRACT MANAGEMENT	3	-	-	-
RELATED FACTORS				
ANALYZE				
REPORTS/DATA	1	1	-	-
ADMINISTRATIVE DELAYS	2	2	-	-

Figure 29
Management Subabilities and Related Factors Associated With Operations Analysis
(Sheet 1 of 2)

IMPLEMENT

	PRIORITY			
	PHASE			
	1	2	3	4
TRADE-OFFS	3	3	-	-
CORRECTIVE ACTION	4	4	-	-

Figure 29
Continued. (Sheet 2 of 2)

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES & FORMATS	1	1	-	-
ANALYZE/ OPTIMIZE				
STANDARD OPERATING PROCEDURES	2	2	-	-
WRITTEN COMMUNICATIONS	-	3	-	-
ORAL COMMUNICATIONS	-	4	-	-
PROCEDURES Overall Mission Operating Maintenance Storage Test Inspection Training	3	5	-	-

Figure 30
Communication Subabilities Associated With Operations Analysis
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE/RECOMMEND				
PLANNING PROCEDURES	1	1	-	-
REQUIREMENTS	2	2	-	-
CONSTRAINTS	3	3	-	-
TRADE-OFFS	4	4	-	-
ASSESSMENT & VERIFICATION	5	5	-	-
RELATED FACTORS				
ANALYZE				
SPECIFICATIONS/STANDARDS	-	1	1	-
REPORTS/DATA	-	2	2	-
DATA FEEDBACK	1	3	3	-
PERFORM				
MATHEMATICAL/STATISTICAL ANALYSIS	-	4	4	-

Figure 31
Program Planning Subabilities and Related Factors Associated With Operations Analysis
(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

ANALYZE/ OPTIMIZE

	PRIORITY			
	PHASE			
	1	2	3	4
MAN/MACHINE INTERFACES	1	1	-	-
TYPE OF PERSONNEL Administrative Maintenance Operations Engineering Support	2	2	-	-
HUMAN ERROR	3	3	-	-
TURN-OVER RATE	4	4	-	-
RELATED FACTORS				
ANALYZE				
GOVERNMENT/CONTRACTOR RELATION	1	1	-	-
WORK LOAD	2	2	-	-
ISOLATION FACTOR	3	3	-	-
EXTENDED WORK SCHEDULES	4	4	-	-

Figure 32
Personnel/Human Factors Subabilities and Related Factors Associated With Operations Analysis
(Sheet 1 of 1)

SYSTEM PERFORMANCE

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
INPUTS	-	1	-	-
OUTPUTS	-	2	-	-
MODES OF OPERATION	1	3	-	-
SYSTEM MODIFICATIONS	-	4	-	-
HUMAN ERROR	-	5	-	-
CATASTROPHIC FAILURES	-	6	-	-
DEGRADATION	2	7	-	-
FEASIBILITY/ EVALUATION				
MISSION GOALS	3	8	-	-
VULNERABILITY	4	9	-	-
SENSITIVITY	5	10	-	-
HIGHLY SPECIALIZED MISSION				
Accuracy	6	11	-	-
Frequency	7	12	-	-
Length	8	13	-	-

Figure 33
System Performance Subabilities and Related Factors Associated With Operations Analysis
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
ROUTINE MISSION				
Accuracy	9	14	-	-
Frequency	10	15	-	-
Length	11	16	-	-
RELATED FACTORS				
ANALYZE				
REPORTS/DATA	1	1	-	-
EVALUATE				
ALTERNATE ACTION	2	2	-	-
FLEXIBILITY	3	3	-	-

Figure 33

Continued. (Sheet 2 of 2)

LOGISTICS

SUBABILITIES

ANALYZE

	PRIORITY PHASE 1	PRIORITY PHASE 2	PRIORITY PHASE 3	PRIORITY PHASE 4
FACILITIES	1	1	-	-
SOURCES OF SUPPLY	2	2	-	-
SPARES	3	3	-	-
TURN-AROUND-TIME	4	4	-	-
EVALUATE				
STORAGE	5	5	-	-
HANDLING	6	6	-	-
RELATED FACTORS				
ANALYZE				
LOGISTICS DATA	1	1	-	-
DELAYS Purchasing Administrative Military	2	2	-	-
INVENTORY	3	3	-	-

Figure 34
Logistics Subabilities and Related Factors Associated With Operations Analysis
(Sheet 1 of 2)

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
MAINTENANCE PHILOSOPHY	4	4	-	-
CONTRACTOR MAINTENANCE	5	5	-	-

Figure 34
Continued. (Sheet 2 of 2)

ENGINEERING FUNCTION

SYSTEMS ANALYSIS/
SYSTEMS ENGINEERING

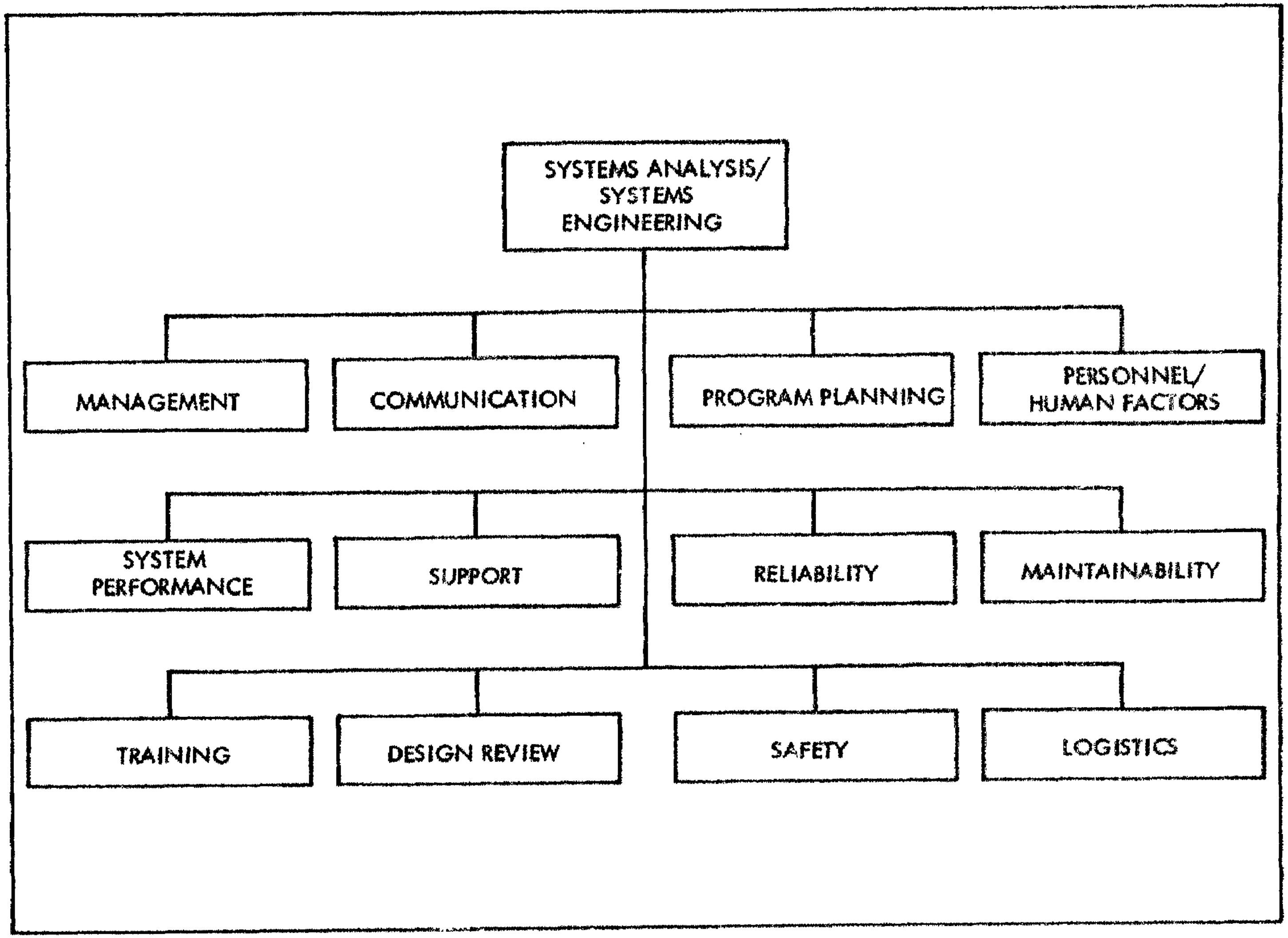

Figure 35. Constituent Abilities Relating to Systems Analysis/Systems Engineering

MANAGEMENT

SUBABILITIES

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	-
ADMINISTRATIVE Planning Organization Scheduling Coordination Procedures	2	2	2	-
COORDINATE				
CONTRACT MANAGEMENT	3	3	3	-
CONFIGURATION MANAGEMENT	4	4	4	-
RELATED FACTORS				
ANALYZE				
REPORTS/DATA	-	1	1	-
ADMINISTRATIVE DELAYS	-	2	2	-

Figure 36
Management Subabilities and Related Factors Associated With
Systems Analysis/Systems Engineering
(Sheet 1 of 2)

IMPLEMENT

	PRIORITY			
	PHASE			
	1	2	3	4
TRADE-OFF STUDIES	-	3	3	-
CORRECTIVE ACTION	-	4	4	-

Figure 36
Continued. (Sheet 2 of 2)

COMMUNICATION

SUBABILITIES

ANALYZE

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
PROCEDURES Overall Mission Operating Maintenance Test Training	1	1	1	-
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	2	2	2	-
STANDARD OPERATING PROCEDURES	3	3	3	-
EXTRA-SITE COMMUNICATIONS	-	4	4	-
INTRA-SITE COMMUNICATIONS	-	4	4	-
INTER-SITE COMMUNICATIONS	-	4	4	-
OPERATIONS AND TECHNICAL MANUALS	-	5	5	-

Figure 37
Communication Subabilities Associated With
Systems Analysis/Systems Engineering
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
DEFINE				
MISSION ELEMENTS	1	1	-	-
TASK DESCRIPTIONS	2	2	1	-
TIME PHASING	3	3	2	-
MILESTONES	4	4	3	-
ESTABLISH				
REQUIREMENTS	5	5	-	-
GOALS	6	6	-	-
CONSTRAINTS	7	7	4	-
TRADE-OFFS	8	8	5	-
MANUFACTURING SUPPORT	9	9	6	-
FIELD SUPPORT	10	10	7	1
ANALYZE				
PLANNING PROCEDURES	11	11	-	-

Figure 38
Program Planning Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
ASSESSMENT AND VERIFICATION	12	12	8	-
RELATED FACTORS				
ANALYZE				
SPECIFICATIONS/STANDARDS	1	1	1	-
MATHEMATICAL/STATISTICAL ANALYSES	-	2	2	-
REPORTS/DATA	-	3	3	-
DATA FEEDBACK	2	4	4	-

Figure 38

Continued. (Sheet 2 of 2)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

SUBABILITIES	PRIORITY PHASE 1	2	3	4
ANALYZE				
TYPES OF PERSONNEL Operations Maintenance Logistics Administrative	1	1	-	-
NUMBER OF PERSONNEL	2	2	-	-
MAN-MACHINE INTERFACES	3	3	-	-
EVALUATE				
ACCESSIBILITY	-	4	-	-
WORK SPACE	-	5	-	-
ARTIFICIAL ENVIRONMENTS	-	6	-	-
CONSIDER				
LIGHTING	-	7	-	-
NOISE	-	8	-	-
HUMAN ERROR	-	9	-	-

Figure 39
Personnel/Human Factors Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering
(Sheet 1 of 2)

RELATED FACTORS

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
DEVICES Warning Signalling Displays Controls	-	1	-	-
WORKLOAD	-	2	-	-
CONSIDER				
DEMANDS Mental Physical	-	3	-	-
PERSONNEL ADAPTATION	-	4	-	-

Figure 39
Continued. (Sheet 2 of 2)

SYSTEM PERFORMANCE

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
INPUTS	1	1	1	-
OUTPUTS	2	2	2	-
MODES OF OPERATION	3	3	3	-
SYSTEM MODIFICATIONS	-	4	4	-
EVALUATE				
MISSION GOALS	4	5	5	-
MISSION Accuracy Frequency Length	5	6	6	-
TOLERANCES Mission Electrical Instrument Frequency	-	7	7	-
DEGRADATION	-	8	8	-
PRIME POWER	6	9	9	-
ELECTROMAGNETIC INTERFERENCE	7	10	10	-
GOVERNMENT FURNISHED EQUIPMENT	8	11	11	-

Figure 40
System Performance Subabilities and Related Factors Associated With
Systems Analysis/Systems Engineering
(Sheet 1 of 2)

RELATED FACTORS	PRIORITY PHASE 1	2	3	4
ANALYZE				
REPORTS/DATA	1	1	1	-
EVALUATE				
SPECIFICATIONS & DRAWINGS	-	2	2	-
DETERMINE				
FLEXIBILITY	2	3	3	-
ALTERNATE ACTION	3	4	4	-
INFORMATION SECURITY	4	5	5	-

Figure 40

Continued. (Sheet 2 of 2)

SUPPORT

SUBABILITIES

DETERMINE

	PRIORITY PHASE 1	2	3	4
COMPATIBILITY	1	1	1	-
FACILITIES	2	2	2	-
SITE SELECTION	3	3	3	-
INSTALLATION REQUIREMENTS	4	4	4	-
RELATED FACTORS				
EVALUATE				
MAINTENANCE	-	1	1	-

Figure 41
Support Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering
(Sheet 1 of 1)

RELIABILITY

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
REQUIREMENTS	1	1	-	-

RELATED FACTORS

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
STATE-OF-THE-ART DEVICES	1	1	1	-

Figure 42
Reliability Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering
(Sheet 1 of 1)

MAINTAINABILITY

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
REQUIREMENTS	1	1	-	-
ESTABLISH				
MAINTENANCE PHILOSOPHY	2	2	-	-
RELATED FACTORS				
ESTABLISH				
STANDARDIZATION	1	1	1	-
EVALUATE				
CONTINUOUS OPERATION CONSTRAINTS	2	2	-	-

Figure 43
Maintainability Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering
(Sheet 1 of 1)

TRAINING

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
RECOMMEND				
SPECIAL TRAINING DEVICES	-	1	1	-
SPECIALIZED EQUIPMENT TRAINING	-	2	2	-
EVALUATE				
TRAINING LEVEL REQUIREMENTS	1	3	3	-

Figure 44
Training Subabilities and Related Factors Associated With
Systems Analysis/Systems Engineering
(Sheet 1 of 1)

DESIGN REVIEW

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
SYSTEM CONSIDERATIONS	1	1	1	-
CONCEPTUAL DESIGN	2	-	-	-
ELECTRICAL DESIGN	3	2	2	-
MECHANICAL DESIGN	4	3	3	-
SAFETY FACTORS	5	4	4	-
COMPATIBILITY	6	5	5	-
SUBCONTRACT ITEMS	-	6	6	-
STANDARDIZATION	-	7	7	-
DETERMINE				
FREQUENCY OF REVIEW	-	8	8	-
DURATION OF REVIEW	-	9	9	-
CONSIDER				
PACKAGING	7	10	10	-
RELIABILITY	8	11	11	-

Figure 45
Design Review Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
MAINTAINABILITY	9	12	12	-
RELATED FACTORS				
EVALUATE				
TEST PROCEDURES	-	1	1	-

Figure 45
Continued. (Sheet 2 of 2)

SAFETY

SUBABILITIES

EVALUATE

	PRIORITY PHASE 1	2	3	4
HAZARDS *Mechanical* *Electrical*	1	1	-	-
INHERENT DANGERS	2	2	-	-
PROTECTION DEVICES	-	3	-	-
WARNING DEVICES	-	4	-	-
SPECIAL ELECTRONIC DEVICES	-	5	-	-

RELATED FACTORS

CONSIDER

	PRIORITY PHASE 1	2	3	4
SAFETY DEFICIENCIES	1	1	-	-

Figure 46

Safety Subabilities and Related Factors Associated With Systems Analysis/Systems Engineering

(Sheet 1 of 1)

LOGISTICS

SUBABILITIES

EVALUATE

RELATED FACTORS

EVALUATE

	PRIORITY PHASE 1	2	3	4
SUBABILITIES				
SPARES	1	1	-	-
SOURCES OF SUPPLY	2	2	-	-
FACILITIES	3	3	-	-
TRANSPORTATION	4	4	-	-
TURN-AROUND TIME	5	5	-	-
HARDWARE Standard Parts Packaging	6	6	-	-
STORAGE	7	7	-	-
HANDLING	8	8	-	-
RELATED FACTORS				
INTERCHANGEABILITY	1	1	-	-

Figure 47
Logistics Subabilities and Related Factors Associated With
Systems Analysis/Systems Engineering
(Sheet 1 of 2)

CONSIDER

	PRIORITY			
	PHASE			
	1	2	3	4
PURCHASING SUPPORT	2	2	-	-
MAINTENANCE PHILOSOPHY	3	3	-	-
SELECTED SPECIAL PARTS	4	4	-	-
CUSTOM REQUIREMENTS	5	5	-	-

Figure 47
Continued. (Sheet 2 of 2)

LOGISTICS/SUPPORT

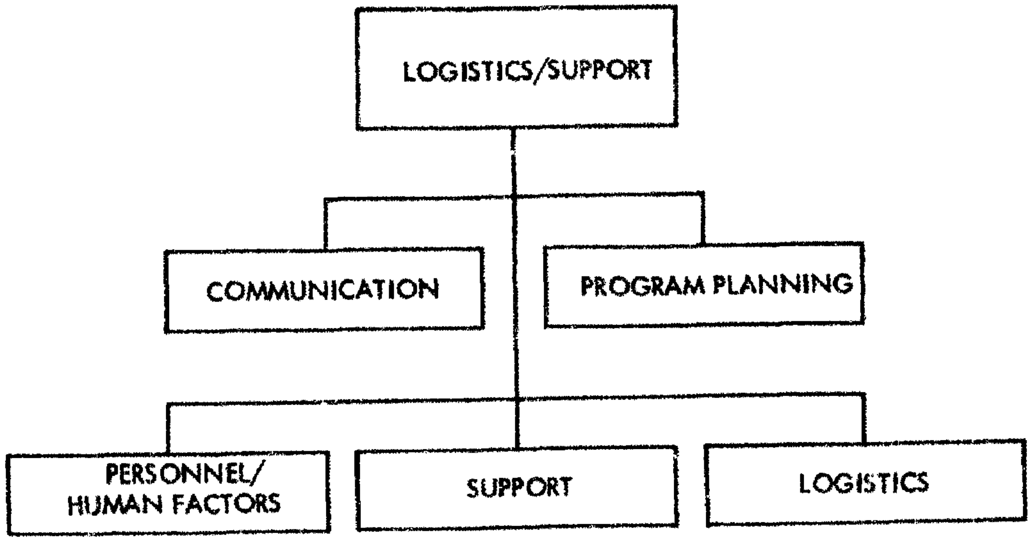

Figure 48. Constituent Abilities Relating to Logistics/Support

COMMUNICATION

SUBABILITIES

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
PROCEDURES Overall Mission Operating Storage Inspection	1	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES & FORMATS	2	2	2	-
STANDARD OPERATING PROCEDURES	3	3	3	-
GOVERNMENT-CONTRACTOR COMMUNICATION	4	4	4	-
WRITTEN COMMUNICATIONS	5	5	5	-
ORAL COMMUNICATIONS	6	6	6	-
OPERATIONS AND TECHNICAL MANUALS	-	-	7	-

Figure 49
Communication Subabilities Associated With
Logistics/Support
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES	PRIORITY PHASE 1	2	3	4
ANALYZE				
MISSION ELEMENTS	1	1	1	-
PLANNING PROCEDURES	2	2	2	-
ESTABLISH				
GOALS	3	3	-	-
REQUIREMENTS	4	4	-	-
CONSTRAINTS	5	5	-	-
TRADE-OFFS	6	6	-	-
DEVELOP				
PROGRAM PLANS (LOGISTICS & SUPPORT) Task Descriptions Time Phasing Milestones	-	7	3	-
DEFINE				
FIELD SUPPORT	7	8	4	-

Figure 50
Program Planning Subabilities and Related Factors Associated With Logistics/Support
(Sheet 1 of 2)

RELATED FACTORS

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
SPECIFICATIONS/STANDARDS	1	1	1	-
REPORTS/DATA	2	2	2	-
DATA FEEDBACK	-	3	3	-

Figure 50
Continued. (Sheet 2 of 2)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
TYPE OF PERSONNEL Logistics Support Administration	1	1	1	-
SKILL LEVELS	2	2	2	-
NUMBER OF PERSONNEL	-	3	3	-
RELATED FACTORS				
EVALUATE				
WORK LOAD	-	1	1	-
ISOLATION FACTOR	-	2	2	-
JANITORIAL SERVICES	-	3	3	-

Figure 51
Personnel/Human Factors Subabilities and Related Factors Associated With Logistics Support
(Sheet 1 of 1)

SUPPORT

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
CONTRACT REQUIREMENTS	1	1	1	-
DETERMINE				
BUILDINGS	-	2	2	-
FACILITIES	-	3	3	-
COMPATIBILITY	-	4	4	-
RELATED FACTORS				
IMPLEMENT				
PROGRAM PLAN	-	-	1	-
EVALUATE				
SITE REAL ESTATE	-	1	2	-
MAINTENANCE	-	-	3	-

Figure 52
Support Subabilities and Related Factors Associated With
Logistics/Support
(Sheet 1 of 1)

LOGISTICS

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
ANALYZE				
CONTRACT REQUIREMENTS	1	1	1	-
TURN-AROUND TIME	2	2	2	-
SOURCES OF SUPPLY	3	3	3	-
TRANSPORTATION	-	4	4	-
DELIVERY	-	-	5	-
SPARES	-	5	6	-
EVALUATE				
STANDARD PARTS	-	6	7	-
HARDWARE PACKAGING	-	7	8	-
HANDLING	-	-	9	-
STORAGE	-	-	10	-
SUPPLY OF DOCUMENTS	-	-	11	-
DETERMINE				
FREQUENT DOCUMENT CHANGES	-	-	12	-

Figure 53
Logistics Subabilities and Related Factors Associated With Logistics/Support
(Sheet 1 of 2)

RELATED FACTORS

	PRIORITY PHASE 1	2	3	4
IMPLEMENT				
LOGISTICS PROGRAM PLAN	-	-	1	-
ANALYZE				
LOGISTICS DATA	-	1	2	-
PROCEDURES Requisition Storage	-	2	3	-
PURCHASING SUPPORT	-	3	4	-
DELAYS Administrative Military Purchasing	-	4	5	-
INVENTORY	-	-	6	-
BREAKAGE IN TRANSIT	-	-	7	-

Figure 53
Continued. (Sheet 2 of 2)

DESIGN ENGINEERING

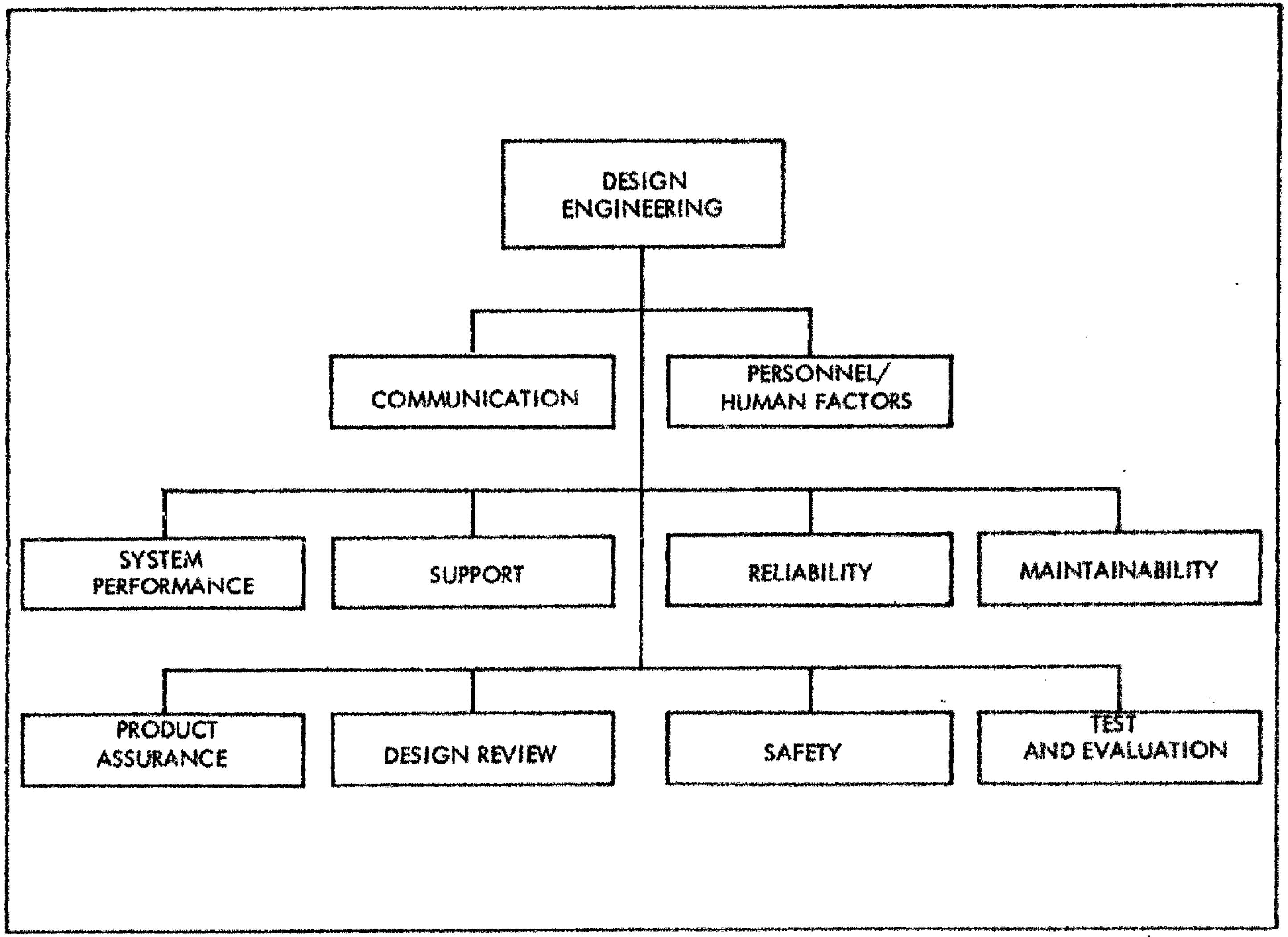

Figure 54. Constituent Abilities Relating to Design Engineering

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
PROVIDE				
TECHNICAL INPUT FOR PROCEDURES Overall Mission Operating Maintenance Test Inspection Training Storage	-	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	-	2	-
STANDARD OPERATING PROCEDURES	-	-	3	-
GOVERNMENT CONTRACTOR COMMUNICATION	-	-	4	-
WRITTEN COMMUNICATIONS	-	-	5	-
ORAL COMMUNICATIONS	-	-	6	-

Figure 55
Communication Subabilities Associated With
Design Engineering
(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
UTILIZE				
HUMAN ENGINEERING PROGRAM PLAN	-	-	1	-
EVALUATE				
REQUIREMENTS	-	-	2	-
CONSTRAINTS	-	-	3	-
INITIATE				
CORRECTIVE ACTION	-	-	4	-

RELATED FACTORS

	PRIORITY PHASE 1	2	3	4
ISOLATE				
DISCREPANCIES	-	-	1	-

Figure 56
Personnel/Human Factors Subabilities and Related Factors Associated With Design Engineering
(Sheet 1 of 1)

SYSTEM PERFORMANCE

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
MODES OF OPERATION	-	1	1	-
INPUTS	-	2	2	-
OUTPUTS	-	3	3	-
TRANSIENTS	-	4	4	-
PRIME POWER	-	5	5	-
POWER SUPPLY	-	6	6	-
PRIME POWER FLUCTUATION	-	-	7	-
ELECTRICAL INTERFERENCE	-	7	8	-
SIGNAL BANDWIDTH	-	8	9	-
SIGNAL FREQUENCY	-	9	10	-
NOISE FIGURE	-	10	11	-
PROPAGATION CHANGES	-	11	12	-
EVALUATE				
MISSION GOALS	-	12	13	-
HUMAN ERROR	-	13	14	-

Figure 57
System Performance Subabilities and Related Factors Associated With Design Engineering
(Sheet 1 of 4)

	PRIORITY			
	PHASE			
	1	2	3	4
SYSTEM MODIFICATIONS	-	14	15	-
CATASTROPHIC FAILURES	-	15	16	-
COMPATIBILITY	-	16	17	-
HIGHLY SPECIALIZED MISSION Accuracy Frequency Length	-	17	18	-
ROUTINE MISSION Accuracy Frequency Length	-	18	19	-
TOLERANCES Mission Pre-Launch Post-Launch Electrical Mechanical Frequency Cooling System Thermal	-	19	20	-
RANGE	-	20	21	-
WEIGHT	-	21	22	-
COST	-	22	23	-

Figure 57
Continued. (Sheet 2 of 4)

	PRIORITY PHASE 1	2	3	4
RECOVERY TIME	-	23	24	-
DEGRADATION	-	24	25	-
SENSITIVITY	-	25	26	-
VULNERABILITY	-	26	27	-
ELECTRONIC COUNTER MEASURE	-	27	28	-
RECALIBRATION	-	29	30	-
GOVERNMENT FURNISHED EQUIPMENT	-	29	30	-
INITIATE/ IMPLEMENT				
CORRECTIVE ACTION	-	30	31	-
RELATED FACTORS				
DEVELOP				
TECHNICAL INPUTS FOR PURCHASING	-	-	1	-

Figure 57
Continued. (Sheet 3 of 4)

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
SPECIFICATIONS AND DRAWINGS	-	1	2	-
PRODUCTION	-	2	3	-
ANALYZE				
LOSS OF SIGNAL	-	-	4	-
REPORTS/DATA	-	3	5	-
CONSIDER				
ALTERNATE ACTION	-	4	6	-
FLEXIBILITY	-	5	7	-
COST INFORMATION	-	6	8	-
INFORMATION SECURITY	-	7	9	-

Figure 57
Continued. (Sheet 4 of 4)

SUPPORT

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
FACILITIES	-	-	1	-
BUILDINGS	-	-	2	-
DEVELOP				
INSTALLATION REQUIREMENTS	-	-	3	-
ENSURE				
COMPATIBILITY	-	-	4	-

Figure 58
Support Subabilities Associated With
Design Engineering
(Sheet 1 of 1)

RELIABILITY

	PRIORITY PHASE 1	2	3	4
SUBABILITIES				
UTILIZE				
RELIABILITY PROGRAM PLAN	-	-	1	-
EVALUATE				
REQUIREMENTS	-	-	2	-
CONSTRAINTS	-	-	3	-
INITIATE				
CORRECTIVE ACTION	-	-	4	-
RELATED FACTORS				
ISOLATE				
DISCREPANCIES	-	-	1	-

Figure 59
Reliability Subabilities and Related Factors Associated With Design Engineering
(Sheet 1 of 1)

MAINTAINABILITY

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
UTILIZE				
MAINTAINABILITY PROGRAM PLAN	-	-	1	-
EVALUATE				
REQUIREMENTS	-	-	2	-
CONSTRAINTS	-	-	3	-
INITIATE				
CORRECTIVE ACTION	-	-	4	-
RELATED FACTORS				
ISOLATE				
DISCREPANCIES	-	-	1	-

Figure 60
Maintainability Subabilities and Related Factors Associated With Design Engineering
(Sheet 1 of 1)

PRODUCT ASSURANCE

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
UTILIZE				
PRODUCT ASSURANCE PROGRAM PLAN	-	-	1	-
EVALUATE				
REQUIREMENTS	-	-	2	-
CONSTRAINTS	-	-	3	-
INITIATE				
CORRECTIVE ACTION	-	-	4	-
RELATED FACTORS				
ISOLATE				
DISCREPANCIES	-	-	1	-

Figure 61
Product Assurance Subabilities and Related Factors Associated With
Design Engineering
(Sheet 1 of 1)

DESIGN REVIEW

SUBABILITIES

EVALUATE

	PRIORITY PHASE 1	2	3	4
DESIGN Conceptual Electrical Mechanical	-	-	1	-
SYSTEM CONSIDERATIONS	-	-	2	-
CIRCUIT CONSIDERATIONS	-	-	3	-
COMPONENT PART SELECTION	-	-	4	-
COMPONENT PART APPLICATION	-	-	5	-
COMPATIBILITY	-	-	6	-
PACKAGING	-	-	7	-
SAFETY FACTORS	-	-	8	-
RELIABILITY	-	-	9	-
MAINTAINABILITY	-	-	10	-
PRODUCIBILITY	-	-	11	-
MATERIALS AND PROCESSES	-	-	12	-
SUB-CONTRACT ITEMS	-	-	13	-
DESIGN DISCLOSURE FORMAT	-	-	14	-

Figure 62
Design Review Subabilities and Related Factors Associated With Design Engineering
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
CONFIGURATION CONTROL	-	-	15	-
INITIATE				
CORRECTIVE ACTION	-	-	16	-
IMPLEMENT				
STANDARDIZATION	-	-	17	-
RELATED FACTORS				
EVALUATE				
TEST PROCEDURES	-	-	1	-
ELECTRICAL INTERFERENCE	-	-	2	-

Figure 62
Continued. (Sheet 2 of 2)

SAFETY

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
UTILIZE				
SAFETY ENGINEERING PLAN	-	-	1	-
EVALUATE				
REQUIREMENTS	-	-	2	-
CONSTRAINTS	-	-	3	-
INITIATE				
CORRECTIVE ACTION	-	-	4	-
RELATED FACTORS				
ISOLATE				
DISCREPANCIES	-	-	1	-

Figure 63
Safety Subabilities and Related Factors Associated With
Design Engineering
(Sheet 1 of 1)

TEST AND EVALUATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
TEST SPECIFICATIONS	-	-	1	-
TEST STANDARDS	-	-	2	-
TEST PROCEDURES	-	-	3	-
CONSIDER				
REQUIREMENTS Test Calibration	-	-	4	-
CATEGORIES I, II, AND III SYSTEM TESTING	-	-	5	-
PART TESTING	-	-	6	-
TESTS Environmental Test-to-Failure System Storage Handling Tests Tactical Usage Tests	-	-	7	-

Figure 64
Test and Evaluation Subabilities Associated With
Design Engineering
(Sheet 1 of 1)

RELIABILITY/MAINTAINABILITY ENGINEERING

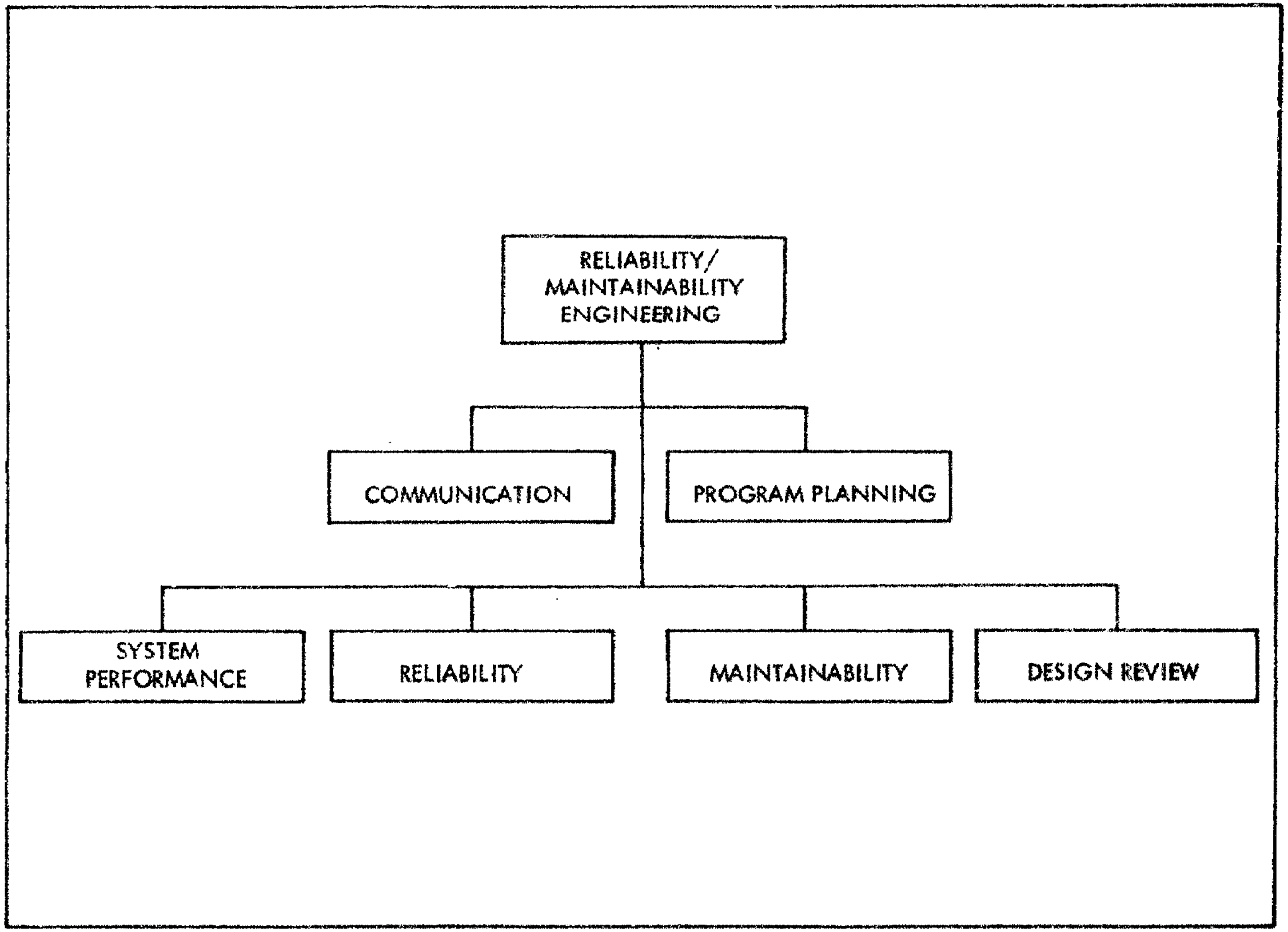

Figure 65. Constituent Abilities Relating to Reliability/Maintainability Engineering

COMMUNICATION

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
PROCEDURES Overall Mission Test Maintenance Operating Inspection Failure Data Collection	-	1	1	1
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	1	2	2	-
STANDARD OPERATING PROCEDURES	2	3	3	-
GOVERNMENT-CONTRACTOR COMMUNICATION	-	4	4	-
WRITTEN COMMUNICATIONS	3	5	5	-
ORAL COMMUNICATIONS	4	6	6	-

Figure 66
Communication Subabilities Associated With
Reliability/Maintainability Engineering
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
MISSION ELEMENTS	1	1	1	-
PLANNING PROCEDURES	2	2	2	-
ESTABLISH				
GOALS	3	3	-	-
REQUIREMENTS	4	4	-	-
CONSTRAINTS	5	5	-	-
TRADE-OFFS	6	6	-	-
DEVELOP				
PROGRAM PLANS Task Descriptions Time Phasing Milestones	-	7	3	-

Figure 67
Program Planning Subabilities and Related Factors Associated With Reliability/Maintainability Engineering
(Sheet 1 of 2)

RELATED FACTORS

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
SPECIFICATIONS AND STANDARDS	1	1	1	-
REPORTS/DATA	2	2	2	1
DATA FEEDBACK	-	3	3	2
PERFORM				
MATHEMATICAL/STATISTICAL ANALYSIS	-	4	4	3

Figure 67
Continued. (Sheet 2 of 2)

SYSTEM PERFORMANCE

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	-
MISSION GOALS	2	2	2	-
MISSION Accuracy Frequency Length	3	3	3	-
MODES OF OPERATION	4	4	4	-
INPUTS	-	5	5	-
OUTPUTS	-	6	6	-
COMPATIBILITY	-	7	7	-
CATASTROPHIC FAILURES	-	8	8	1
DEGRADATION	-	9	9	2
TOLERANCES Mission Electrical Mechanical Instrument Frequency Thermal	-	10	10	-
ELECTROMAGNETIC INTERFERENCE	-	-	11	-

Figure 68

System Performance Subabilities and Related Factors Associated With Reliability/Maintainability Engineering

(Sheet 1 of 3)

	PRIORITY			
	PHASE			
	1	2	3	4
HUMAN ERROR	-	11	12	3
PRIME POWER FLUCTUATION	-	12	13	-
TRANSIENTS	-	13	14	-
RECOVERY TIME	5	14	15	-
HIGH PRECISION	6	15	16	-
RANGE	7	16	17	-
DATA RECOVERY TIME	-	17	18	-
ELECTRONIC COUNTERMEASURES	8	18	19	-
RECOMMEND				
ALTERNATE ACTION	9	19	20	-

Figure 68
Continued. (Sheet 2 of 3)

RELATED FACTORS	PRIORITY PHASE 1	2	3	4
ANALYZE				
REPORTS/DATA	1	1	1	1
LOSS OF SIGNAL	-	-	2	2
EVALUATE				
SPECIFICATIONS AND DRAWINGS	-	2	3	-
FLEXIBILITY	-	3	4	-

Figure 68
Continued. (Sheet 3 of 3)

RELIABILITY

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
ANALYZE				
REQUIREMENTS	1	1	1	–
MODES OF OPERATION	2	2	2	–
REDUNDANCY	3	3	3	–
DERATING	–	–	4	–
TOLERANCES Electrical Mechanical Thermal	–	–	5	–
SHOCK	–	–	6	–
VIBRATION	–	–	7	–
ELECTROMAGNETIC INTERFERENCE	–	–	8	–
EVALUATE				
CONSTRAINTS	4	4	9	–
CRITICAL ELEMENTS	–	–	10	–

Figure 69
Reliability Subabilities and Related Factors Associated With
Reliability/Maintainability Engineering
(Sheet 1 of 4)

	Priority Phase 1	Priority Phase 2	Priority Phase 3	Priority Phase 4
HARDWARE Interfaces Standard Parts Printed Wiring Microelectronics	5	5	11	-
MONITOR/ EVALUATE				
TEST/DEMONSTRATION	-	-	12	1
PERFORMANCE	-	-	13	2
RECOMMEND				
CORRECTIVE ACTION	6	6	14	3

Figure 69
Continued. (Sheet 2 of 4)

RELATED FACTORS

	PRIORITY PHASE 1	2	3	4
DEVELOP/ IMPLEMENT				
PROGRAMS Reliability Program Plan Field Failure Feedback Program	-	1	1	-
ANALYZE				
FAILURE MODE AND EFFECTS	-	2	2	-
FIELD FAILURE DATA	-	-	3	1
PERFORM				
RELIABILITY PREDICTION	1	3	4	-
EVALUATE				
DESIGN CHANGES	-	-	5	-
STATE-OF-THE-ART DEVICES	2	4	6	-
AIR CONDITIONING	3	5	7	-

Figure 69

Continued. (Sheet 3 of 4)

ISOLATE

DISCREPANCIES	PRIORITY			
	PHASE			
	1	2	3	4
	4	6	8	2

Figure 69
Continued. (Sheet 4 of 4)

MAINTAINABILITY

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
REQUIREMENTS	1	1	1	-
EVALUATE				
MAINTENANCE PHILOSOPHY	2	2	2	-
MAINTENANCE Depot Field Organizational	3	3	3	-
ACCESSIBILITY	-	4	4	-
LOCALIZATION	4	5	5	-
TEST POINTS	-	6	6	-
PACKAGING	5	7	7	-
INTERCHANGEABILITY	-	8	8	-
OVERHAUL REQUIREMENTS	-	9	9	-
CALIBRATION REQUIREMENTS	-	10	10	-
REPLACEABILITY	-	11	11	-
MOUNTING REQUIREMENTS	-	-	12	-

Figure 70
Maintainability Subabilities and Related Factors Associated With Reliability/Maintainability Engineering
(Sheet 1 of 4)

	PRIORITY			
	PHASE			
	1	2	3	4
INSPECTABILITY	-	-	13	-
HANDLING REQUIREMENTS	-	-	14	-
STORAGE REQUIREMENTS	-	12	15	-
CONSTRAINTS	6	13	16	-
MONITOR/ EVALUATE				
TEST/DEMONSTRATION	-	-	17	1
FIELD PERFORMANCE	-	-	18	2
RECOMMEND				
CORRECTIVE ACTION	7	14	19	3

Figure 70
Continued. (Sheet 2 of 4)

RELATED FACTORS	PRIORITY PHASE 1	2	3	4
DEVELOP/ IMPLEMENT				
PROGRAMS	-	1	1	-
Maintainability Program Plan				
Maintenance Data Feedback Program				
ANALYZE				
MAINTENANCE DATA	-	-	2	1
PERFORM				
MAINTAINABILITY PREDICTION	-	2	3	-
EVALUATE				
DOCUMENTATION	-	3	4	-
Maintenance Procedures				
Technical Manuals				
Routine Paper work Requirements				
DESIGN CHANGES	-	4	5	-
CONTINUOUS OPERATION CONSTRAINTS	-	5	6	-
TROUBLESHOOTING TECHNIQUES	-	6	7	-

Figure 70
Continued. (Sheet 3 of 4)

	PRIORITY			
	PHASE			
	1	2	3	4
ADMINISTRATIVE DELAY TIME	-	7	8	2
SAFETY HAZARDS	-	8	9	3
STANDARDIZATION	1	9	10	-
SPARE PARTS	-	10	11	-
TECHNICIAN CAPABILITY	-	-	12	-
ISOLATE				
DISCREPANCIES	2	11	13	4

Figure 70
Continued. (Sheet 4 of 4)

DESIGN REVIEW

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
SYSTEM CONSIDERATIONS	1	1	1	-
CONCEPTUAL DESIGN	2	2	2	-
ELECTRICAL DESIGN	-	3	3	-
MECHANICAL DESIGN	-	4	4	-
CIRCUIT CONSIDERATION	-	5	5	-
COMPONENT PART SELECTION	-	6	6	-
COMPONENT PART APPLICATION	-	7	7	-
PACKAGING	-	8	8	-
PRODUCIBILITY	-	-	9	-
MATERIALS AND PROCESSES	-	-	10	-
SUBCONTRACT ITEMS	-	9	11	-
DESIGN DISCLOSURE FORMAT	-	10	12	-
STANDARDIZATION	-	11	13	-

Figure 71
Design Review Subabilities and Related Factors Associated With Reliability/Maintainability Engineering
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
DETERMINE				
FREQUENCY OF REVIEW	-	12	14	-
PERSONNEL PARTICIPATING	-	13	15	-
DURATION OF REVIEW	-	14	16	-
RECOMMEND				
CORRECTIVE ACTION	-	15	17	-
RELATED FACTORS				
EVALUATE				
TEST PROCEDURES	-	1	1	-
ELECTRICAL INTERFACES	-	2	2	-
ISOLATE				
DISCREPANCIES	-	3	3	-

Figure 71
Continued. (Sheet 2 of 2)

HUMAN ENGINEERING/
SAFETY ENGINEERING

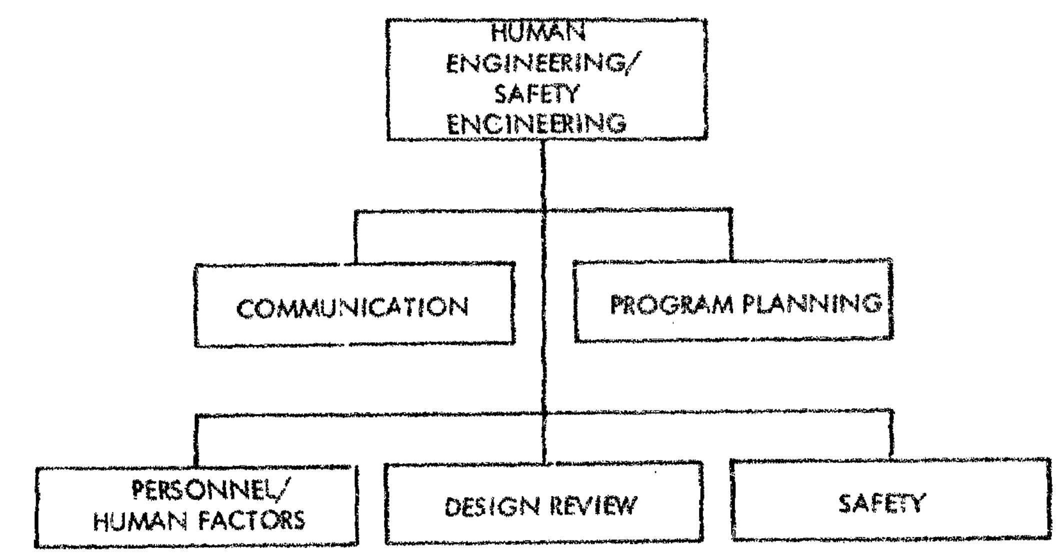

Figure 72. Constituent Abilities Relating to Human Engineering/Safety Engineering

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
PROCEDURES Overall Mission Operating Maintenance Test Training Storage Inspection	-	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	1	2	2	-
STANDARD OPERATING PROCEDURES	2	3	3	-
GOVERNMENT-CONTRACTOR COMMUNICATION	3	4	4	-
WRITTEN COMMUNICATIONS	4	5	5	-
ORAL COMMUNICATIONS	5	6	6	-

Figure 73
Communication Subabilities Associated With
Human Engineering/Safety Engineering
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
MISSION ELEMENTS	1	1	1	-
PLANNING PROCEDURES	2	2	2	-
ESTABLISH				
GOALS	3	3	-	-
REQUIREMENTS	4	4	-	-
CONSTRAINTS	5	5	-	-
TRADE-OFFS	6	6	3	-
DEVELOP				
PROGRAM PLANS (SAFETY & HUMAN ENGINEERING) Task Descriptions Time Phasing Milestones	-	7	4	-

Figure 74
Program Planning Subabilities and Related Factors Associated With Human Engineering/Safety Engineering
(Sheet 1 of 2)

RELATED FACTORS

	PRIORITY PHASE 1	2	3	4
ANALYZE				
SPECIFICATIONS AND STANDARDS	1	1	1	-
REPORTS/DATA	2	2	2	-
DATA FEEDBACK	-	3	3	-
PERFORM				
MATHEMATICAL/STATISTICAL ANALYSIS	-	4	4	-

Figure 74
Continued. (Sheet 2 of 2)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
TYPE OF PERSONNEL Operations Maintenance	-	1	1	-
SKILL LEVELS	-	2	2	-
NUMBER OF PERSONNEL	-	3	3	-
MAN MACHINE INTERFACES	-	4	4	-
EVALUATE				
INHERENT DANGER	-	4	4	-
HAZARDS Mechanical Electrical	-	5	5	-
HUMAN ERROR	-	-	6	-
LIGHTING	-	-	7	-
NOISE	-	-	8	-
WORK SPACE	-	6	9	-
ACCESSIBILITY	-	-	10	-
ARTIFICIAL ENVIRONMENTS	-	-	11	-

Figure 75
Personnel/Human Factors Subabilities and Related Factors Associated With Human Engineering/Safety Engineering
(Sheet 1 of 2)

RELATED FACTORS	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
DEVICES Warning Signalling Displays Controls	-	-	1	-
IMPLEMENT				
HUMAN ENGINEERING PROGRAM PLAN	-	-	2	-

Figure 75
Continued. (Sheet 2 of 2)

DESIGN REVIEW

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
CONCEPTUAL DESIGN	1	1	1	-
ELECTRICAL DESIGN	-	-	2	-
MECHANICAL DESIGN	-	-	3	-
SYSTEM CONSIDERATIONS	-	-	4	-
COMPATIBILITY	-	-	5	-
PACKAGING	-	-	6	-
RECOMMEND				
CORRECTIVE ACTION	-	-	7	-
RELATED FACTORS				
ISOLATE				
DISCREPANCIES	-	-	1	-

Figure 76
Design Review Subabilities and Related Factors Associated With Human Engineering/Safety Engineering
(Sheet 1 of 1)

SAFETY

SUBABILITIES	PRIORITY PHASE 1	2	3	4
ANALYZE				
INHERENT DANGERS	-	1	1	-
HAZARDS Mechanical Electrical	-	2	2	-
EVALUATE				
SAFETY DEVICES AND SHIELDS	-	-	3	-
WARNING DEVICES	-	-	4	-
IMPLEMENT				
SAFETY CONTROL	-	3	5	-
ACCIDENT/INCIDENT REPORTS	-	-	6	1

Figure 77
Safety Subabilities and Related Factors Associated With
Human Engineering/Safety Engineering
(Sheet 1 of 2)

RELATED FACTORS	PRIORITY			
	PHASE			
	1	2	3	4
IMPLEMENT				
SAFETY ENGINEERING PLAN	-	-	1	-
ANALYZE				
SAFETY DATA	-	-	2	1
SAFETY DEFICIENCIES	-	-	3	2

Figure 77

Continued. (Sheet 2 of 2)

TEST/DEMONSTRATION

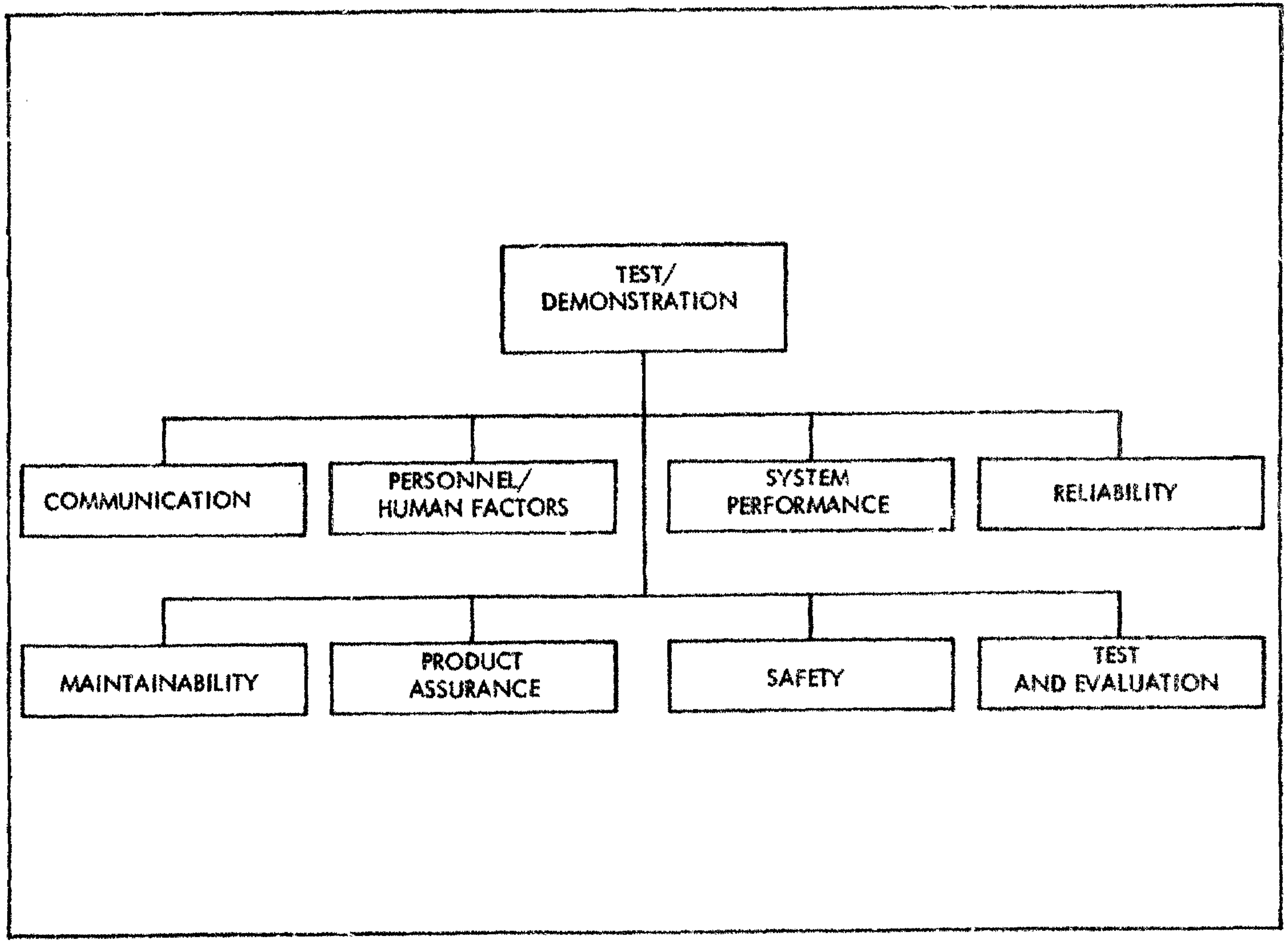

Figure 78. Constituent Abilities Relating to Test/Demonstration

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
PROCEDURES Overall Mission Operating Maintenance	-	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	2	2	-
STANDARD OPERATING PROCEDURES	-	3	3	-
GOVERNMENT CONTRACTOR COMMUNICATION	-	4	4	-
WRITTEN COMMUNICATIONS	-	5	5	-
ORAL COMMUNICATIONS	-	6	6	-
PROVIDE				
INPUT FOR TECHNICAL MANUALS	-	-	7	-

Figure 79
Communication Subabilities Associated With
Test/Demonstration
(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
CONTRACT REQUIREMENTS	-	1	1	-
PROGRAM PLAN REQUIREMENTS	-	2	2	-
ESTABLISH				
SCHEDULES	-	3	3	-

RELATED FACTORS

	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
DESIGN CHANGES	-	1	1	-

Figure 80
Personnel/Human Factors Subabilities and Related Factors Associated With Test/Demonstration
(Sheet 1 of 1)

SYSTEM PERFORMANCE

SUBABILITIES

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	-
MISSION GOALS	2	2	2	-
MISSION Accuracy Frequency Length	3	3	3	-
HIGHLY SPECIALIZED MISSION Accuracy Frequency Length	4	4	4	-
ROUTINE MISSION Accuracy Frequency Length	5	5	5	-
TOLERANCES Mission Electrical Mechanical Pre-Launch Post-Launch Instrument Frequency Cooling System Thermal	-	6	6	-
MODES OF OPERATION	6	7	7	-

Figure 81
System Performance Subabilities and Related Factors Associated With Test/Demonstration
(Sheet 1 of 3)

	PRIORITY			
	PHASE			
	1	2	3	4
INPUTS	-	8	8	-
OUTPUTS	-	9	9	-
CAPACITY	-	10	10	-
VULNERABILITY	-	11	11	-
COMPATIBILITY	-	12	12	-
ELECTROMAGNETIC INTERFERENCE	-	13	13	-
EVALUATE				
SIGNAL Bandwidth Frequency	-	14	14	-
PRIME POWER FLUCTUATION	-	15	15	-
POWER SUPPLY	-	16	16	-
NOISE FIGURE	-	17	17	-
TRANSIENTS	-	18	18	-
ELECTRONIC COUNTERMEASURES	-	19	19	-

Figure 81

Continued. (Sheet 2 of 3)

RELATED FACTORS

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
SPECIFICATIONS AND DRAWINGS	-	1	1	-
REPORTS/DATA	-	2	2	-
ALTERNATE ACTION	-	3	3	-

Figure 81
Continued. (Sheet 3 of 3)

RELIABILITY	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
CONTRACT REQUIREMENTS	-	1	1	-
PROGRAM PLAN REQUIREMENTS	-	2	2	-
ESTABLISH				
SCHEDULE	-	3	3	-
RELATED FACTORS				
EVALUATE				
DESIGN CHANGES	-	-	1	1

Figure 82
Reliability Subabilities and Related Factors Associated With Test/Demonstration
(Sheet 1 of 1)

	PRIORITY			
	PHASE			
	1	2	3	4
MAINTAINABILITY				
SUBABILITIES				
EVALUATE				
CONTRACT REQUIREMENTS	-	1	1	-
PROGRAM PLAN REQUIREMENTS	-	2	2	-
ESTABLISH				
SCHEDULE	-	3	3	-
RELATED FACTORS				
EVALUATE				
DESIGN CHANGES	-	-	1	1

Figure 83
Maintainability Subabilities and Related Factors Associated With Test/Demonstration
(Sheet 1 of 1)

PRODUCT ASSURANCE

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
CONTRACT REQUIREMENTS	-	1	1	-
PROGRAM PLAN REQUIREMENTS	-	2	2	-
ESTABLISH				
SCHEDULE	-	3	3	-
RELATED FACTORS				
EVALUATE				
DESIGN CHANGES	-	1	1	-

Figure 84
Product Assurance Subabilities and Related Factors Associated With Test/Demonstration
(Sheet 1 of 1)

SAFETY

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
EVALUATE				
CONTRACT REQUIREMENTS	-	1	1	-
PROGRAM PLAN REQUIREMENTS	-	2	2	-
ESTABLISH				
SCHEDULE	-	3	3	-
RELATED FACTORS				
EVALUATE				
DESIGN CHANGES	-	1	1	-

Figure 85

Safety Subabilities and Related Factors Associated With Test/Demonstration

(Sheet 1 of 1)

TEST AND EVALUATION

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
CONTRACT REQUIREMENTS	-	1	1	-
REQUIREMENTS OF ALL PROGRAM PLANS	-	2	2	-
TEST Specifications Standards Procedures Configurations Sequences	-	3	3	-
SIMULTANEOUS TESTING	-	4	4	-
ESTABLISH				
TEST/DEMONSTRATION Schedules Calibration Requirements	-	5	5	-
DEVELOP				
TEST AND EVALUATION PROGRAM PLAN	-	6	6	-

Figure 86
Test and Evaluation Subabilities Associated With
Test/Demonstration
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
PERFORM				
CALIBRATION	-	7	7	-
TESTS/DEMONSTRATIONS (CATEGORIES I, II, III)	-	8	8	-
System Performance				
Reliability				
Maintainability				
Product Assurance				
Safety				
Installation				
Human Engineering				
Storage and Handling				
Tactical Usage Tests				
DOCUMENT				
RESULTS	-	9	9	-
PREPARE				
CATEGORIES I, II, AND III TEST REPORTS	-	10	10	-

Figure 86

Continued. (Sheet 2 of 2)

OPERATIONS FUNCTION

PURCHASING

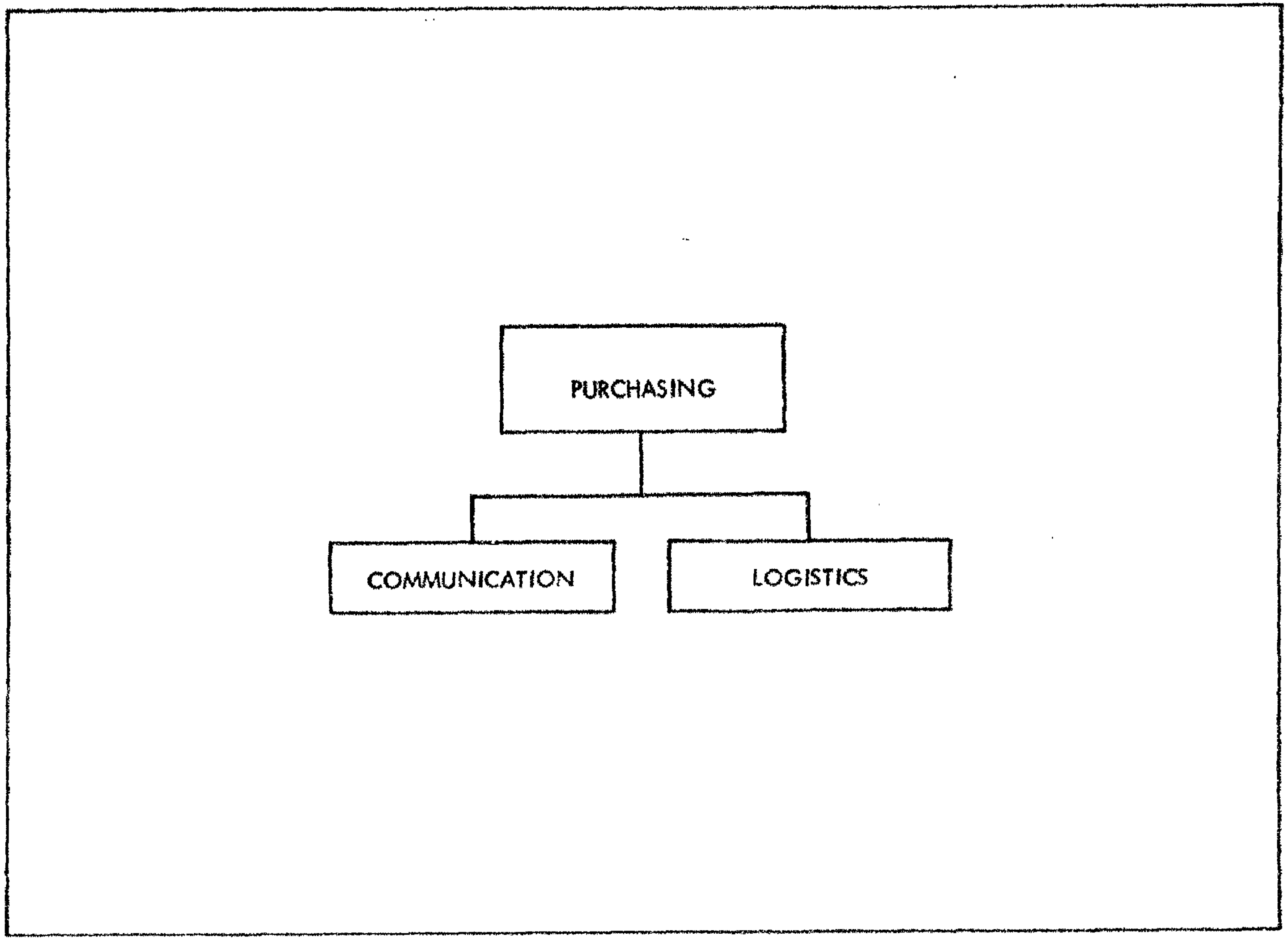

Figure 87. Constituent Abilities Relating to Purchasing

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
DEVELOP/ IMPLEMENT				
STANDARD OPERATING PROCEDURES	-	1	1	-
EVALUATE/ UTILIZE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	2	2	-
EVALUATE				
GOVERNMENT-CONTRACTOR COMMUNICATION	-	3	3	-
WRITTEN COMMUNICATIONS	-	4	4	-
ORAL COMMUNICATIONS	-	5	5	-

Figure 88

Communication Subabilities Associated With Purchasing
(Sheet 1 of 1)

LOGISTICS

SUBABILITIES

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
SOURCES OF SUPPLY	1	1	1	1
FACILITIES	-	2	2	2
TURN-AROUND TIME	-	3	3	3
DELIVERY	-	4	4	4
SPARES	-	5	5	5
TRANSPORTATION	2	6	6	6
SUPPLY OF DOCUMENTS	-	-	7	7
HARDWARE Standard Parts Packaging	-	7	8	8
STORAGE	-	8	9	9
HANDLING	-	-	10	10
GOVERNMENT FL..NISHED EQUIPMENT	3	9	11	-

Figure 89
Logistics Subabilities and Related Factors Associated With Purchasing
(Sheet 1 of 2)

RELATED FACTORS	PRIORITY PHASE 1	2	3	4
ANALYZE				
DELAYS Purchasing Administrative Military	1	1	1	1
LOGISTICS DATA	-	2	2	2
PURCHASING SUPPORT	2	3	3	3
PROCEDURES Requisition Storage	-	4	4	-
INVENTORY	-	-	5	4
BREAKAGE IN TRANSIT	-	-	6	5
EVALUATE				
CONTRACTOR MAINTENANCE	3	5	7	6
CUSTOM REQUIREMENTS	-	6	8	-
SELECTED SPECIAL PARTS	-	-	9	7
CONSIDER				
MAINTENANCE PHILOSOPHY	-	7	10	-

Figure 89
Continued. (Sheet 2 of 2)

PLANNING

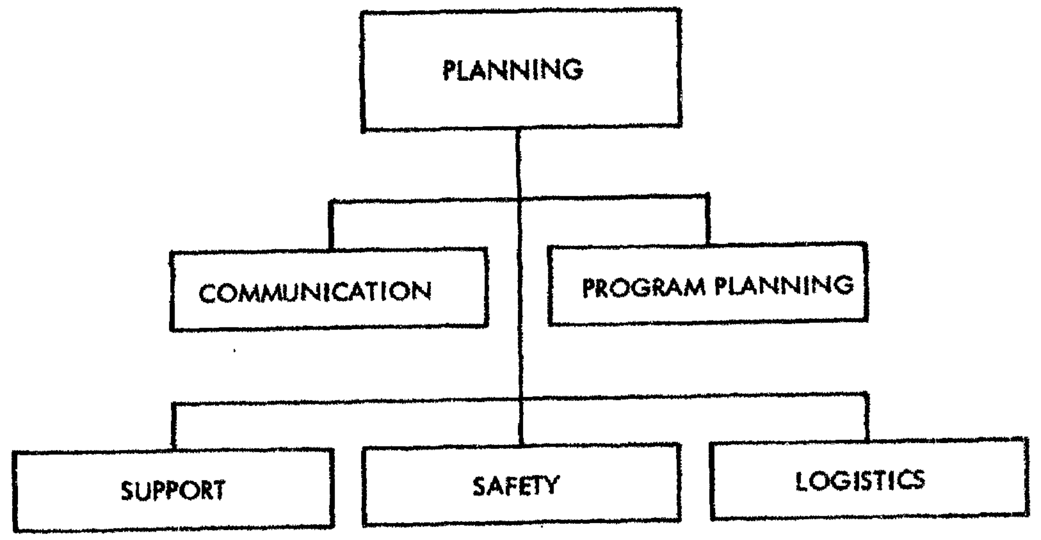

Figure 90. Constituent Abilities Relating to Planning

COMMUNICATION

SUBABILITIES

ANALYZE

	PRIORITY PHASE 1	2	3	4
PROCEDURES Overall Mission Operating Maintenance Test Inspection Storage Training	-	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	2	2	-
STANDARD OPERATING PROCEDURES	-	3	3	-
GOVERNMENT-CONTRACTOR COMMUNICATION	-	4	4	-
WRITTEN COMMUNICATIONS	-	5	5	-
ORAL COMMUNICATIONS	-	6	6	-
OPERATIONS AND TECHNICAL MANUALS	-	7	7	-

Figure 91
Communication Subabilities Associated With Planning
(Sheet 1 of 1)

PROGRAM PLANNING

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE/ DEVELOP				
MISSION	1	1	1	1
CONTRACT REQUIREMENTS	2	2	2	-
TASK DESCRIPTION	-	3	3	-
TIME PHASING	-	4	4	-
MILESTONES	-	5	5	-
CAPABILITY	-	6	6	-
INSTALLATION REQUIREMENTS	-	7	7	-
ESTABLISH				
ORGANIZATION	-	8	8	-
GOALS	-	9	9	-
PROCEDURES	-	10	10	-
SCHEDULES	-	11	11	-
CONTROLS	-	12	12	-
SECURITY REQUIREMENTS	-	13	13	-

Figure 92
Program Planning Subabilities and Related Factors Associated With Planning
(Sheet 1 of 3)

	PRIORITY			
	PHASE			
	1	2	3	4
CONFIGURATION CONTROL	-	14	14	-
MANUFACTURING SUPPORT	-	15	15	-
DETERMINE				
DISCREPANCIES	3	16	16	-
INITIATE				
CORRECTIVE ACTION	4	17	17	-
RELATED FACTORS				
ASSIGN				
RESPONSIBILITY FOR TASK ACCOMPLISHMENT	1	1	1	-

Figure 92
Continued. (Sheet 2 of 3)

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
SPECIFICATIONS AND STANDARDS	2	2	2	-
REPORTS/DATA	3	3	3	-
DATA FEEDBACK	-	4	4	-

Figure 92
Continued. (Sheet 3 of 3)

SUPPORT

	PRIORITY			
	PHASE			
	1	2	3	4
SUBABILITIES				
DETERMINE				
FACILITIES	-	1	1	-
BUILDINGS	-	2	2	-
COMPATIBILITY	-	3	3	1
STORAGE	-	4	4	-
RELATED FACTORS				
EVALUATE				
MAINTENANCE	1	1	1	-
SITE REAL ESTATE	2	2	2	-

Figure 93
Support Subabilities and Related Factors Associated With Planning
(Sheet 1 of 1)

SAFETY

SUBABILITIES

EVALUATE

	PRIORITY PHASE 1	2	3	4
SAFETY CONTROLS	-	1	1	-
HAZARDS Mechanical Electrical	-	2	2	-
SAFETY DEVICES AND SHIELDS	-	-	3	-
WARNING DEVICES	-	-	4	-
SPECIAL ELECTRONIC DEVICES	-	-	5	-

RELATED FACTORS

IMPLEMENT

	1	2	3	4
SAFETY ENGINEERING PLAN	-	-	1	-

Figure 94
Safety Subabilities and Related Factors Associated With Planning
(Sheet 1 of 1)

LOGISTICS

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
SOURCES OF SUPPLY	-	1	1	-
TRANSPORTATION	-	2	2	1
DELIVERY	-	3	3	2
TURN-AROUND TIME	-	4	4	3
FACILITIES	-	5	5	-
SPARES	-	6	6	4
EVALUATE				
HARDWARE Standard Parts Packaging	-	7	7	-
STORAGE	-	8	8	-
HANDLING	-	9	9	-
SUPPLY OF DOCUMENTS	-	10	10	-

Figure 95
Logistics Subabilities and Related Factors Associated With Planning
(Sheet 1 of 2)

RELATED FACTORS	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
MAINTENANCE PHILOSOPHY	1	1	1	-
INTERCHANGEABILITY	-	-	2	-
CUSTOM REQUIREMENTS	-	2	3	-
SELECTED SPECIAL PARTS	-	3	4	-
ANALYZE				
PROCEDURES Storage Requisition	-	4	5	-
DELAYS Purchasing Administrative Military	-	5	6	-
PURCHASING SUPPORT	-	6	7	-
INVENTORY	2	7	8	1
LOGISTICS DATA	-	8	9	1
EVALUATE				
LOGISTICS PROGRAM PLAN	3	9	10	-

Figure 95
Continued. (Sheet 2 of 2)

MANUFACTURING

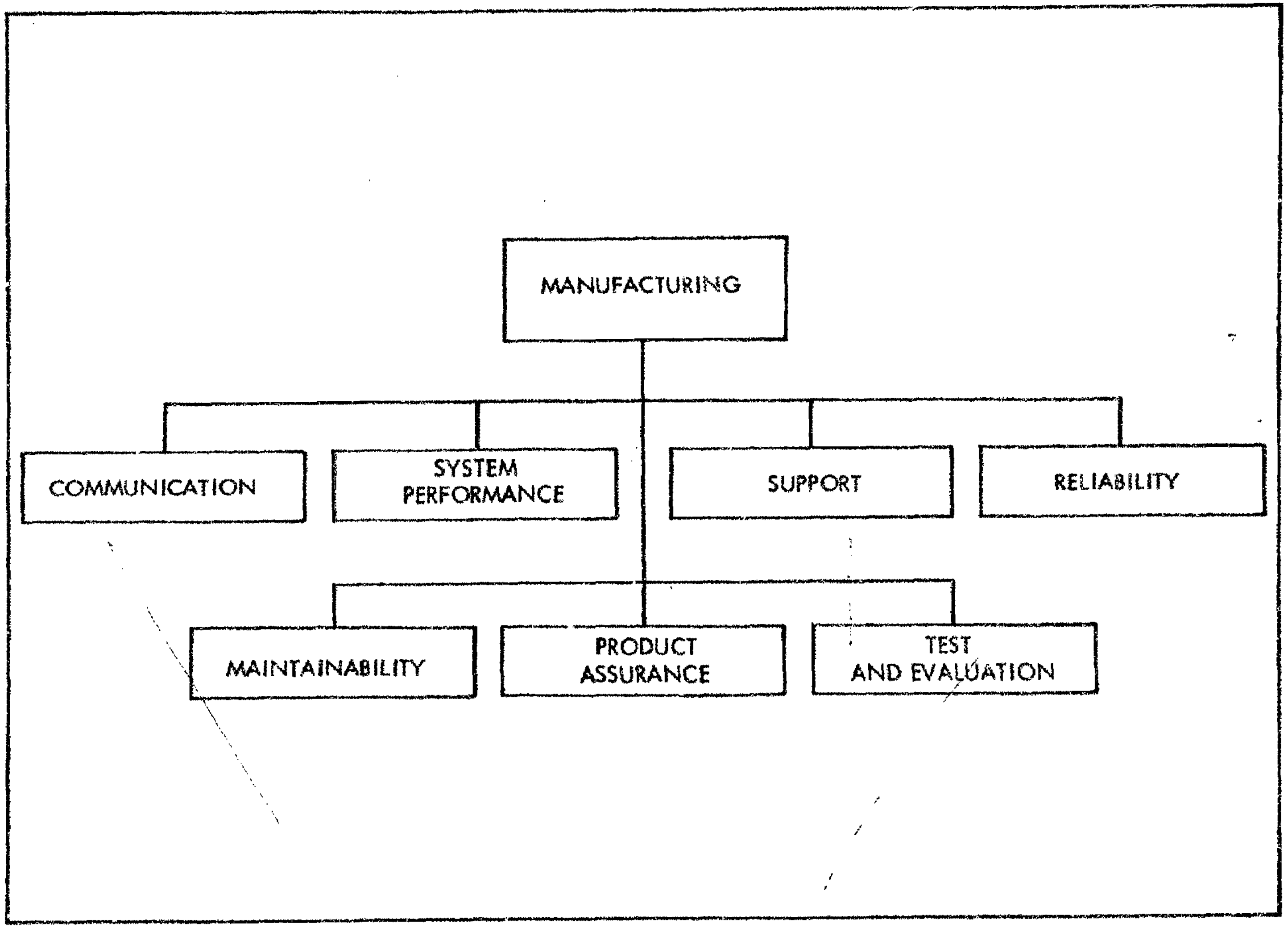

Figure 96. Constituent Abilities Relating to Manufacturing

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
REVIEW				
PROCEDURES Overall Mission Operating Maintenance Test Inspection Storage Training	1	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	2	2	2	-
STANDARD OPERATING PROCEDURES	-	3	3	-
GOVERNMENT-CONTRACTOR COMMUNICATION	3	4	4	-
WRITTEN COMMUNICATIONS	4	5	5	-
ORAL COMMUNICATIONS	5	6	6	-

Figure 97
Communication Subabilities Associated With Manufacturing
(Sheet 1 of 1)

SYSTEM PERFORMANCE

SUBABILITIES

EVALUATE

	PRIORITY PHASE 1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	-
MODES OF OPERATION	2	2	2	-
PRODUCTION	-	3	3	-
INPUTS	3	4	4	-
OUTPUTS	4	5	5	-
PRIME POWER	-	6	6	-
SYSTEM MODIFICATIONS	-	7	7	-
RELATED FACTORS				
EVALUATE				
SPECIFICATIONS AND DRAWINGS	-	1	1	-
OPERATIONS AND TECHNICAL MANUALS	-	2	2	-
PURCHASING	-	3	3	-

Figure 98
System Performance Subabilities and Related Factors Associated With Manufacturing
(Sheet 1 of 2)

DETERMINE

COST INFORMATION

PRIORITY			
PHASE			
1	2	3	4
-	4	4	-

Figure 98

Continued. (Sheet 2 of 2)

SUPPORT

SUBABILITIES

REVIEW

	PRIORITY			
	PHASE			
	1	2	3	4
BUILDINGS	-	1	1	-
FACILITIES	-	2	2	-
STORAGE	-	3	3	-
COMPATIBILITY	-	4	4	1
RELATED FACTORS				
REVIEW				
MAINTENANCE	-	1	1	1

Figure 99
Support Subabilities and Related Factors Associated With Manufacturing
(Sheet 1 of 1)

RELIABILITY

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
MAINTAIN DESIGN INTEGRITY	-	-	1	-
ISOLATE PROBLEM AREAS	-	-	2	-
INITIATE CORRECTIVE ACTION	-	-	3	-

Figure 100
Reliability Subabilities Associated With
Manufacturing
(Sheet 1 of 1)

MAINTAINABILITY

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
MAINTAIN DESIGN INTEGRITY	-	-	1	-
ISOLATE PROBLEM AREAS	-	-	2	-
INITIATE CORRECTIVE ACTION	-	-	3	-

Figure 101
Maintainability Subabilities Associated With Manufacturing
(Sheet 1 of 1)

PRODUCT ASSURANCE

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
WORKMANSHIP	-	-	1	-
ENGINEERING DRAWINGS AND SPECIFICATIONS	-	-	2	-
INITIATE				
CORRECTIVE ACTION	-	-	3	-
RELATED FACTORS				
UTILIZE				
PRODUCT ASSURANCE PROGRAM PLAN	-	-	1	-

Figure 102
Product Assurance Subabilities and Related Factors Associated With Manufacturing
(Sheet 1 of 1)

TEST AND EVALUATION

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
IMPLEMENT				
TEST AND EVALUATION PROGRAM PLAN	-	-	1	-
PERFORM				
CALIBRATION	-	-	2	-
CATEGORY I TESTS	-	-	3	-
DOCUMENT				
RESULTS	-	-	4	-
PREPARE				
CATEGORY I TEST REPORT	-	-	5	-

Figure 103
Test and Evaluation Subabilities Associated With
Manufacturing
(Sheet 1 of 1)

PRODUCT ASSURANCE

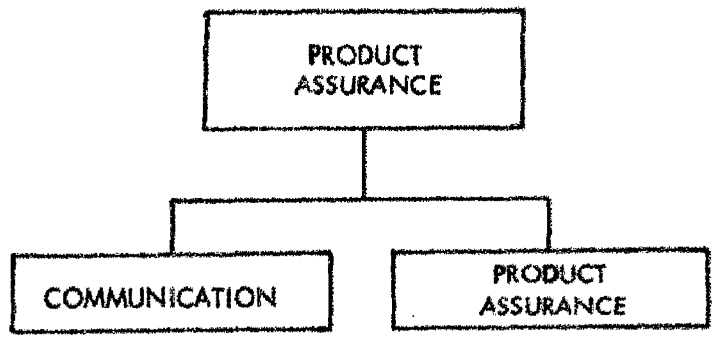

Figure 104. Constituent Abilities Relating to Product Assurance

COMMUNICATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
REVIEW				
PROCEDURES	1	1	1	1
Overall Mission				
Operating				
Maintenance				
Test				
Inspection				
Storage				
Training				
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	2	2	2	-
STANDARD OPERATING PROCEDURES	-	3	3	-
GOVERNMENT-CONTRACTOR COMMUNICATION	3	4	4	-
WRITTEN COMMUNICATIONS	4	5	5	-
ORAL COMMUNICATIONS	5	6	6	-
FAILURE DATA COLLECTION	-	7	7	2

Figure 105
Communication Subabilities Associated With
Product Assurance
(Sheet 1 of 1)

PRODUCT ASSURANCE

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
CONTRACT REQUIREMENTS	1	1	1	-
EVALUATE				
ENGINEERING DRAWINGS AND SPECIFICATIONS	-	2	2	-
WORKMANSHIP	-	-	3	-
PROCUREMENT SPECIFICATIONS	-	3	4	-
PURCHASE ORDERS	-	-	5	-
DEVELOP/ IMPLEMENT				
TEST /DEMONSTRATIONS	-	-	6	1
INSPECTIONS Receiving In-Process Installation Final	-	-	7	2
PERIODIC QUALITY AUDITS	-	-	8	-
VENDOR SURVEILLANCE	-	-	9	-

Figure 106
Product Assurance Subabilities and Related Factors Associated With Product Assurance
(Sheet 1 of 3)

	PRIORITY			
	PHASE			
	1	2	3	4
MATERIAL TESTING	-	-	10	-
MONITOR/ EVALUATE				
TEST AND DEMONSTRATION	-	-	11	3
INITIATE				
CORRECTIVE ACTION	-	-	12	4
RELATED FACTORS				
DEVELOP/ IMPLEMENT				
PRODUCT ASSURANCE PROGRAM PLAN	-	1	1	-

Figure 106
Continued. (Sheet 2 of 3)

IMPLEMENT

CONFIGURATION CONTROL

PRIORITY			
PHASE			
1	2	3	4
-	2	2	-

Figure 106
Continued. (Sheet 3 of 3)

PRODUCT SUPPORT FUNCTION

TECHNICAL PUBLICATIONS

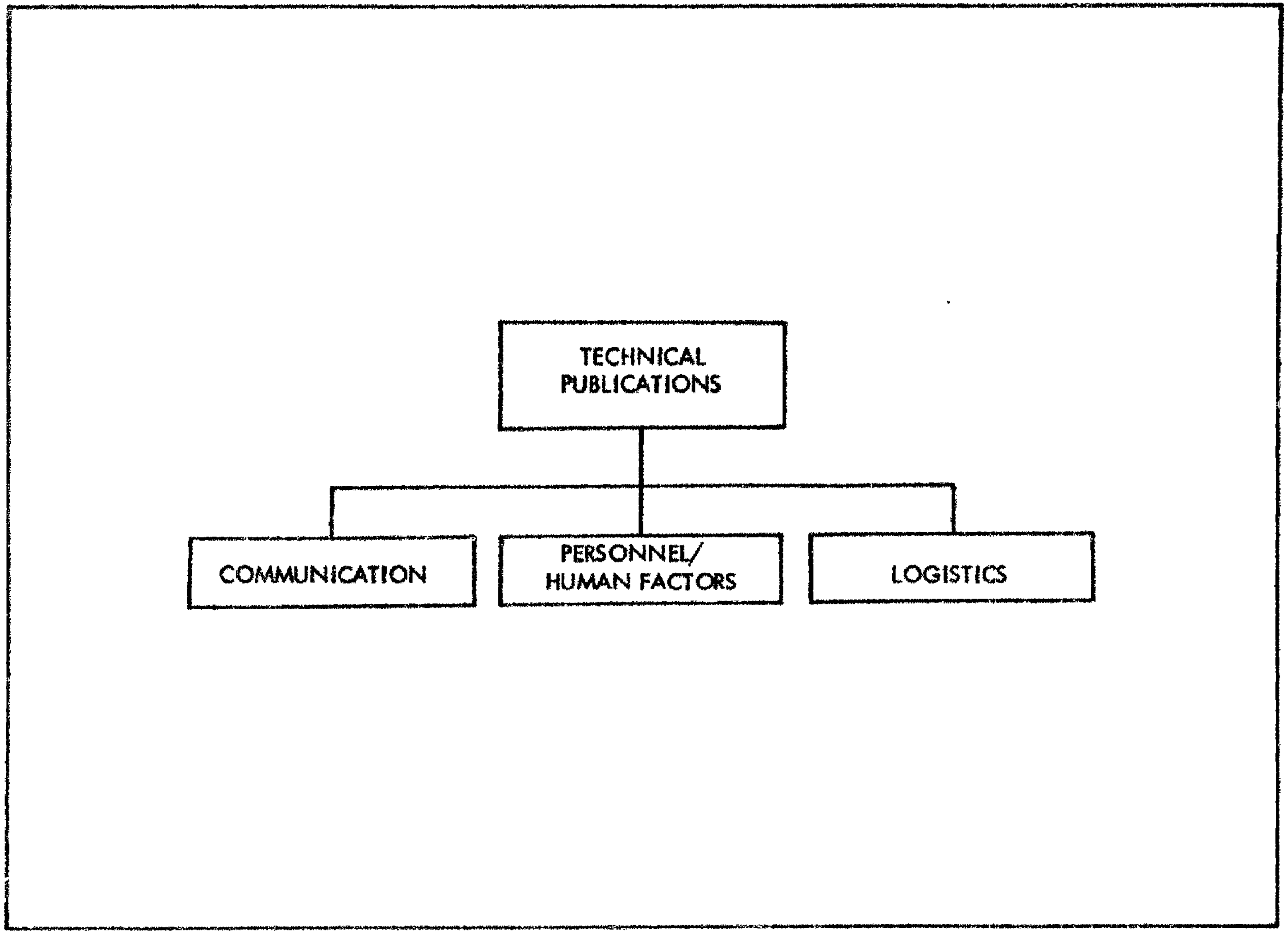

Figure 107. Constituent Abilities Relating to Technical Publications

COMMUNICATION

SUBABILITIES

ANALYZE

	PRIORITY			
	PHASE			
	1	2	3	4
PROCEDURES Operating Maintenance Test Overall Mission Storage Inspection Training	1	1	1	-
EVALUATE				
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	2	2	1
STANDARD OPERATING PROCEDURES	-	3	3	-
WRITTEN COMMUNICATIONS	-	4	4	-
ORAL COMMUNICATIONS	-	5	5	-
GOVERNMENT-CONTRACTOR COMMUNICATION	2	6	6	2
OPERATIONS AND TECHNICAL MANUALS	-	7	7	3

Figure 108
Communication Subabilities Associated With
Technical Publications
(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

ANALYZE/
EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
CONTRACT REQUIREMENTS	1	1	1	-
SPECIFICATIONS AND STANDARDS	-	2	2	-
TYPE OF PERSONNEL Operations Maintenance Logistics Support Engineering	-	3	3	-
SKILL LEVELS	-	4	4	-
SOURCES OF INFORMATION	-	5	5	-
SCHEDULES	-	6	6	-
CIRCULATION	-	7	7	-
ACCURACY	-	8	8	-
COMPLETENESS	-	9	9	-
CLARITY	-	10	10	-
CONCISENESS	-	11	11	-
COMPOSITION	-	12	12	-
PRINTING	-	13	13	-

Figure 109
Personnel/Human Factors Subabilities Associated With
Technical Publications
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
PACKAGING/BINDING	-	14	14	-
IMPLEMENT				
USER REVIEW	-	15	15	-
EXPEDITE				
UPDATING	-	16	17	-

Figure 109

Continued. (Sheet 2 of 2)

LOGISTICS

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
SUPPLY OF DOCUMENTS	-	1	1	1
SOURCES OF SUPPLY	-	2	2	2
DELIVERY	-	3	3	3
TRANSPORTATION	-	4	4	4
HANDLING	-	5	5	5
STORAGE	-	6	6	6

RELATED FACTORS

ANALYZE

	1	2	3	4
PROCEDURES Storage Requisition	-	1	1	1
DELAYS Administrative Purchasing Military	-	2	2	2
PURCHASING SUPPORT	-	3	3	-

Figure 110
Logistics Subabilities and Related Factors Associated With
Technical Publications
(Sheet 1 of 1)

TECHNICAL TRAINING

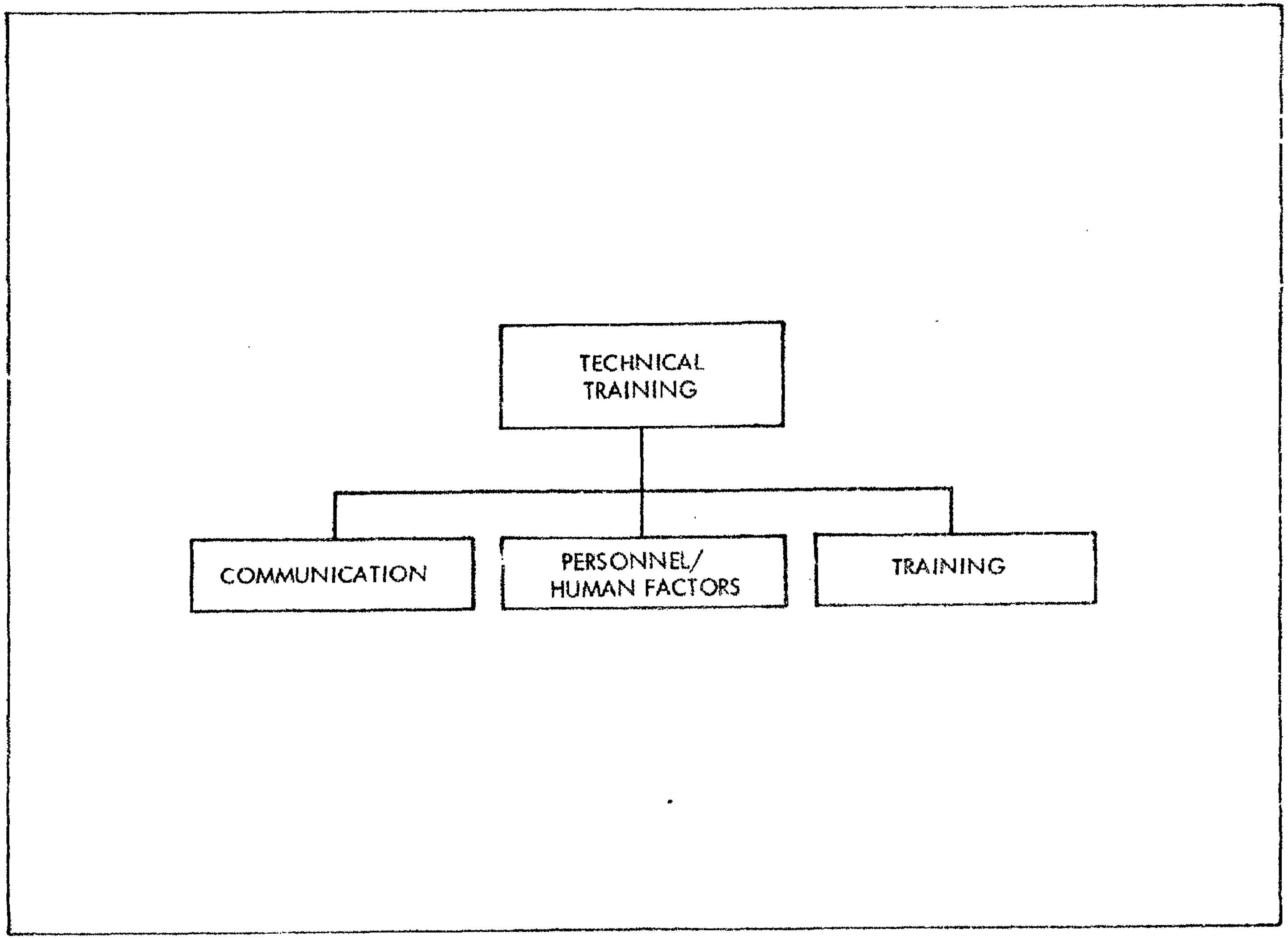

Figure 111. Constituent Abilities Relating to Technical Training

COMMUNICATION

SUBABILITIES

ANALYZE

EVALUATE

	PRIORITY PHASE 1	2	3	4
PROCEDURES Overall Mission Training Operating Maintenance	-	1	1	1
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	2	2	2
STANDARD OPERATING PROCEDURES	-	3	3	3
GOVERNMENT-CONTRACTOR COMMUNICATION	-	4	4	4
WRITTEN COMMUNICATIONS	-	5	5	-
ORAL COMMUNICATIONS	-	6	6	-
OPERATIONS AND TECHNICAL MANUALS	-	7	7	-

Figure 112
Communication Subabilities Associated With Technical Training
(Sheet 1 of 1)

PERSONNEL/HUMAN FACTORS

SUBABILITIES

EVALUATE

	PRIORITY			
	PHASE			
	1	2	3	4
TYPE OF PERSONNEL Maintenance Operations Logistics Administrative	-	1	1	-
SKILL LEVELS	-	2	2	-
NUMBER OF PERSONNEL	-	3	3	-
HUMAN ERROR	-	4	4	-
TURN-OVER RATE	-	5	5	-
NEW PERSONNEL	-	6	6	-
RELATED FACTORS				
ANALYZE				
PERSONNEL Development Adaptation	-	1	1	1

Figure 113
Personnel/Human Factors Subabilities and Related Factors Associated With Technical Training
(Sheet 1 of 2)

	PRIORITY			
	PHASE			
	1	2	3	4
DEMANDS	-	2	2	2
Mental				
Physical				
EVALUATE				
PERSONNEL SELECTION	-	3	3	3

Figure 113
Continued. (Sheet 2 of 2)

TRAINING

SUBABILITIES

	PRIORITY PHASE 1	2	3	4
ANALYZE				
CONTRACT REQUIREMENTS	1	1	1	-
TRAINING LEVEL	2	2	2	-
CURRICULA	-	-	3	-
INSTRUCTORS	-	-	4	-
MATERIAL	-	-	5	-
SPECIAL TRAINING DEVICES	-	-	6	-
SPECIALIZED EQUIPMENT TRAINING	-	-	7	-
CONTRACTOR TRAINING	-	3	8	-
DETERMINE				
NUMBER OF TRAINED PERSONNEL	-	4	9	-
DEVELOP				
PROCEDURES	-	5	10	-
TRAINING EVALUATION PERSONNEL INFORMATION	-	6	11	-

Figure 114
Training Subabilities and Related Factors Associated With
Technical Training
(Sheet 1 of 2)

RELATED FACTORS	PRIORITY			
	PHASE			
	1	2	3	4
EVALUATE				
CONCEPTS	-	1	1	-
FACILITIES	-	2	2	-
TRAINING EQUIPMENT	-	3	3	-
IMPLEMENT				
PLANS	-	-	4	-

Figure 114
Continued. (Sheet 2 of 2)

FIELD ENGINEERING

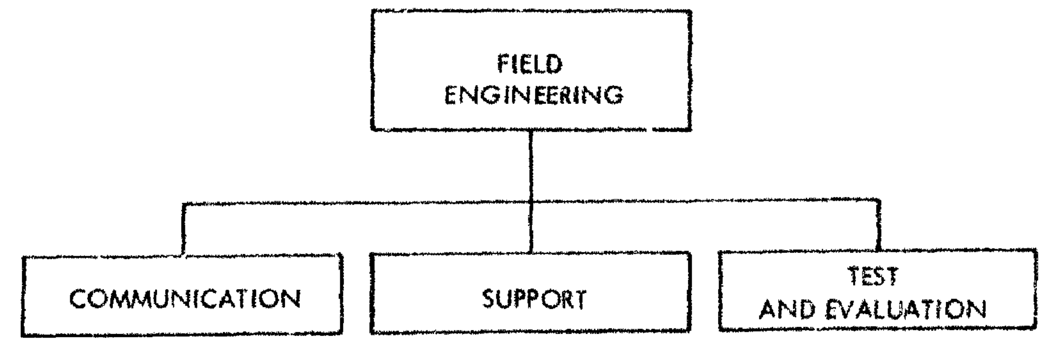

Figure 115. Constituent Abilities Relcting to Field Engineering

COMMUNICATION

SUBABILITIES

IMPLEMENT

	PRIORITY PHASE 1	2	3	4
PROCEDURES Overall Mission Operating Maintenance Test Installation Inspection Storage Training	-	-	1	-

UTILIZE

	PRIORITY PHASE 1	2	3	4
GOVERNMENT STANDARDS, PROCEDURES, & FORMATS	-	-	2	-
STANDARD OPERATING PROCEDURES	-	-	3	-
OPERATIONS AND TECHNICAL MANUALS	-	-	4	-
GOVERNMENT-CONTRACTOR COMMUNICATION	-	-	5	-
WRITTEN COMMUNICATIONS	-	-	6	-
ORAL COMMUNICATIONS	-	-	7	-

Figure 116
Communication Subabilities Associated With
Field Engineering
(Sheet 1 of 1)

SUPPORT

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
ANALYZE				
CONTRACT REQUIREMENTS	-	-	1	-
INSTALLATION PROCEDURES	-	-	2	-
CONSTRUCT				
BUILDINGS	-	-	3	-
FACILITIES	-	-	4	-
PERFORM				
INSTALLATION	-	-	5	-
DOCUMENTATION	-	-	6	-
EVALUATE				
INSTALLATION	-	-	7	-
INITIATE				
CORRECTIVE ACTION	-	-	8	-

Figure 117
Support Subabilities Associated With
Field Engineering
(Sheet 1 of 1)

TEST AND EVALUATION

SUBABILITIES

	PRIORITY			
	PHASE			
	1	2	3	4
IMPLEMENT				
TEST AND EVALUATION PROGRAM PLAN	-	-	1	-
PERFORM				
CALIBRATION	-	-	2	-
CATEGORIES II AND III TESTS	-	-	3	-
DOCUMENT				
RESULTS	-	-	4	-
PREPARE				
CATEGORIES II AND III TEST REPORTS	-	-	5	-

Figure 118
Test and Evaluation Subabilities Associated With
Field Engineering
(Sheet 1 of 1)

APPENDIX IV

Check Lists for Systems Effectiveness Improvement

MANAGEMENT

1. Has the administrative organization been organized to avoid a weak or disorganized structure?

2. Has administrative coordination been maximized by the establishment of program goals and adequate communications throughout the system development cycle?

3. Are all new and existing administrative procedures correct, and do they provide an information feedback loop?

4. Have all administrative delays been identified and minimized?

5. Have the appropriate administrative controls been implemented with caution so that personnel motivation is not hampered?

6. Have conditions that can cause friction between the technicians and their managers been eliminated?

7. Has the administrative personnel capability been evaluated in terms of training and experience for the particular job functions under consideration?

8. Have the management personnel qualifications been matched with the personnel requirements of the system?

9. Have weak, ineffective, and poor materiel management been minimized by adequate consideration of management personnel capability in relation to the system?

10. Has a program been developed to encourage management technique development?

11. Is a good cooperative relationship between government management personnel and system contractor management personnel continually being maintained?

12. Have the contract management functions been integrated with the appropriate system development phases?

13. Are the latest configuration management documents being used to ensure adequate configuration control?

14. Have all available reports and data been reviewed for insight into improving the management structure?

15. Have management procedures for the rapid initiation of corrective action been developed and implemented?

16. Have management guides to trade-off study criteria and computerized trade-off models been developed?

MANAGEMENT
(Con'td.)

17. Have all production schedules been examined for potential bottlenecks and have these schedules been implemented?

18. Has a realistic and practical schedule been implemented?

19. Have all required budgeting plans been effectively made?

20. Has a Value Engineering Program been implemented to the fullest extent?

COMMUNICATION

1. Are all storage, training, maintenance, inspection, operating, and overall mission procedures complete, correct, and unambiguous?

2. Are the standard operating procedures to be used complete, correct, and unambiguous?

3. Have all procedures been examined to ensure that they are sufficiently detailed to handle specification requirements?

4. Have clear procedures for written communications been developed for operations, maintenance, and logistics personnel?

5. Have oral communications procedures been developed where required?

6. Have trade-off studies been conducted to show the need for written communication as compared with oral communication?

7. Have continuous communications between contractor and government personnel been maintained?

8. Have all government standards, procedures, and formats been implemented where requirements for their use exist?

9. Are all technical and operational manuals up to date, easy to read, accurate, and correct?

10. Does the failure reporting format contain all required data elements?

11. Have comprehensive instructions been provided for the completion of all forms?

PROGRAM PLANNING

1. Has the mission been defined?

2. Have all the program goals and the mission requirements been established?

3. Have all the program constraints been identified?

4. Have all the program tasks been identified and defined?

5. Has enough time been allotted to ensure accurate time phasing for the various program tasks?

6. Have all tasks responsibilities been assigned?

7. Have all schedules been realistically developed and coordinated?

8. Has manufacturing and field support considerations been included in the Program Plan?

9. Does the program include assessment and verification requirements?

10. Are the procedures currently in use adequate for the new program?

11. Have all existing reports/data, specifications, and standards been analyzed for use as program inputs or requirements?

12. Has a data feedback system been established to enable a mathematical/statistical analysis of the data collected?

13. Has an integrated Systems Effectiveness Program Plan been developed and implemented?

14. Are PERT techniques being used to optimize Program Plans?

PERSONNEL/HUMAN FACTORS

1. Has the need for future personnel replacements been considered?
2. Has the loss of knowledgeable and well-trained personnel through promotions and turnover been anticipated?
3. Has consideration been given to the effects that new personnel will have on overall system efficiency?
4. Have personnel recruiting and screening procedures been established?
5. Have personnel with the specific experience and training in the various tasks and job requirements been located?
6. Have personnel with good physical and mental adaptability been selected?
7. Have potential operator, maintenance, and logistics personnel error been reduced by providing these personnel with the proper training?
8. Have the required number of operator and maintenance personnel been provided for the system?
9. Has the placing of an individual in an area completely foreign to his experience and training been avoided?
10. Is there an adequate number of personnel available to enable an even distribution of work load?
11. Are all work schedules planned according to the mission requirements?
12. Have any incentive programs been established?
13. Have adequate and comfortable housing been provided for all personnel?
14. Have adequate janitorial services been provided?
15. Has a personnel rotation plan been established to reduce personnel isolation time at remote locations?
16. Are good government contractor relationships being maintained by good communication and coordination?
17. Have personnel been instructed to avoid over confidence and laxity during routine mission?
18. Have current human engineering principles been employed in the design of displays and controls?

PERSONNEL/HUMAN FACTORS
(Con'td.)

19. Are the correct system interfaces being employed?

20. Are marginal interfaces being avoided?

21. Have the required health standards been established for the particular system?

22. Have all unhealthy personnel working conditions been eliminated?

23. Has future system expansion, or increases in equipment hardware been considered in the design of the air conditioning system?

24. Has personnel heat fatigue been avoided by designing a reliable air conditioning system?

25. Have personnel been provided with adequate work space?

26. Has adequate lighting been supplied to reduce or minimize eye strain and fatigue?

27. Have the high noise levels, particularly noise caused by generators, been reduced to a comfortable level?

28. Has an adequate supply of rations, including a reserve supply for emergencies, been provided for site personnel?

29. Are the correct man-machine interfaces, particularly for operators and maintenance personnel, being maintained?

30. Does the design allow for maximum accessibility for maintenance personnel?

31. Have all the necessary system signalling and warning devices been provided to protect operating and maintenance personnel?

32. Has systems design been reviewed to reduce unreasonable mental and physical demands on operating personnel?

33. Have the Personnel/Human Factors requirements been integrated into the Systems Effectiveness Program Plan.

SYSTEM PERFORMANCE

1. Have mission goals been clearly defined without ambiguities?

2. Does the system have the capability to function properly in a highly specialized mission where certain unique functions must be performed?

3. Does the system have adequate patch capability for the mission requirements?

4. Have system modifications and retrofit programs been avoided or minimized?

5. Have all required system modifications been implemented quickly?

6. Has the system been protected against natural and man-induced electromagnetic interference?

7. Have the effects of system locations in relation to wave propagation been considered?

8. Are all the system input and output requirements adequately described and quantified?

9. Are all the system outputs being observed to ensure that the desired outputs are being obtained?

10. Have all the required system modes of operation been established and their impact on systems performance analyzed?

11. Is all the system hardware compatible?

12. Has system/equipment weight been reduced whenever and wherever possible?

13. Does the equipment meet the high repeatibility requirements of the various mission plans?

14. Does the equipment have the capability to operate continually if required to do so by the mission plan?

15. Has the equipment been designed with minimum checkout time requirements?

16. Has the system equipment design considered the problem of recalibration during short recovery time between missions?

17. Has the system/equipment been designed with the capability to meet all mission goals?

18. Does the system design maximize alternate modes of operation thereby giving the system further flexibility?

19. Has the system been designed to maximize reliability?

20. Has the system been designed to limit its susceptibility to propagation changes?

21. Has a design review been conducted throughout all phases of the design?

22. Has a system of procedures and controls for specifications and drawings been implemented to ensure a smooth operation between the various engineering departments?

23. Do all the available design specifications and drawings have the latest issue, and are they correct and accurate?

24. Does the design include a method of failure localization that will quickly and effectively identify the failed components?

25. Have mission tolerances been designed to maintain a low false detection rate?

26. Have the pre-launch requirements been examined for possible implementation of broader tolerances during this phase of the mission?

27. Have all the high precision requirements been identified and satisfied?

28. Has narrow tolerance control during the post-launch phase of the mission been maintained?

29. Have narrow electrical tolerances been avoided in the non-critical segments of the system?

30. Have instruments with sufficiently accurate tolerances been employed to ensure compliance with system tolerances?

31. Are narrow frequency tolerances being maintained for the measurement and alignment of system receivers and transmitters as well as for mission accuracy?

32. Have the cooling system tolerances been established to keep the system temperature within reasonable limits?

33. Has a backup power source been supplied for the main system power source?

34. Have provisions been made to compensate for fluctuations in the prime power supply?

35. Has the criticality of the power supply been minimized by ensuring that all specification requirements have been met?

SYSTEM PERFORMANCE
(Con'td.)

36. Does the design have provisions for defense against electronic countermeasures?

37. Have narrow signal bandwidths been maintained to eliminate or reduce electronic countermeasures?

38. Have provisions been made to ensure that adequate data handling equipment are available during short data recovery time requirements?

39. Has sufficient data handling equipment, or an interrupt routine in the data handling program, been provided to avoid data pile-up?

40. Do the selected system components have low degradation rates?

41. Have provisions been made to protect the system hardware against contamination and corrosion?

42. Have security procedures been established to handle all levels of classified data?

43. Have the specified range requirements been properly identified and defined?

44. Have costs been reduced wherever possible without sacrificing system performance?

45. Have transients been eliminated, particularly in semiconductor applications?

46. Has sufficient lead time for purchasing activities been allowed?

47. Have adequate personnel training programs been introduced to increase personnel knowledge of the system, and reduce human errors?

48. Have all System Performance requirements been integrated into the Systems Effectiveness Program Plan?

SUPPORT

1. Have the buildings been designed with sufficient room for system expansion as well as air conditioning expansion?

2. Has adequate building and facility maintenance been provided?

3. Have the system designers and the support designers been given adequate opportunities for communication and coordination to ensure compatibility between the system hardware and the support hardware?

4. Have adequate temperature controls been installed to avoid uneven temperature distribution (i.e., hot spots and cold spots) throughout the facility?

5. Have potential problems such as electromagnetic interference been considered?

6. Are the storage areas located close to the system site?

7. Have all site surveys been completed?

8. Have all present and potential real estate problems been identified?

9. Have all support requirements been integrated into the Systems Effectiveness Program Plan?

RELIABILITY

1. Has the appropriate type of reliability prediction, relative to the available inputs at each stage of system design or development, been performed or employed?

2. Has each prediction been evaluated and the proper design corrective action initiated?

3. Has preference been given to devices of known reliability over unproven state-of-the-art devices, and devices with custom requirements?

4. Has proper consideration been given to the quantification of reliability in all planning and procurement documents?

5. Have electrical and mechanical tolerance limits that are narrower than necessary been avoided?

6. Have extremely narrow tolerances for antenna systems been avoided?

7. Are the thermal tolerances narrow enough to meet the needs of the overall system?

8. Are all hardware interfaces correct and have any interfaces been omitted?

9. Have all marginal hardware interfaces been avoided or eliminated?

10. Can microelectronic devices be employed in applications where high density packaging/high reliability devices have the highest priority?

11. Are proper screening techniques being employed for microelectronic devices?

12. Is there adequate redundancy for all anticipated mission loads or conditions?

13. Have the parts been sufficiently derated to operate effectively under the anticipated stresses?

14. Has the impact of derated parts on other parameters such as size and weight been considered?

15. Have all high electrical stresses on power output devices been minimized?

16. Have the following been adequately considered?

    a. High or marginal levels of electromagnetic interference (adjacent and co-location interference).

    b. Enemy countermeasures which may produce electromagnetic interference.

17. Have all modes of operation been sufficiently identified and considered?

18. Have the shock and vibration levels encountered in waveguide applications been analyzed to reduce the effect of these loads?

19. Do printed circuits have adequate shock load protection?

20. Have vibration loads, to be experienced by the equipment during transportation, been analyzed or considered?

21. Has an integrated Reliability Program Plan, that is compatible with the system being designed, been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

22. Has a Field Failure Feedback Program been developed and implemented?

23. Has a failure mode and failure effects analysis been conducted for the system and its prime and auxiliary power sources?

24. Based on the analysis of failure modes and effects, has the design been modified to eliminate or minimize the failure effects?

25. Have all design changes been evaluated by considering the appropriate trade-off criteria?

26. Have all the design changes been coordinated with the various functional activities such as publications, training, etc.?

27. Are adequate safety and warning devices being provided to eliminate potential hazards?

28. If equipment changes are necessary, has the appropriate effort been made to update or modify the air conditioning system?

29. Does the system provide for adequate ventilation to allow cooling in the event of air conditioning failures?

30. Have the correct computational and basic data elements been selected?

31. Have time delays in data storage and retrieval been minimized?

32. Have critical elements or devices that have a high failure rate or high adjustment rate been avoided or eliminated?

33. Is maximum use being made of standard parts throughout the system design?

34. Has the use of special devices been avoided or only employed when absolutely necessary?

MAINTAINABILITY

1. Has the maintenance philosophy been established?

2. Has a Maintainability Program Plan been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

3. Does the design meet the requirements of the Maintainability Program Plan and the maintenance philosophy?

4. Has a Field Failure Feedback Program been developed and implemented?

5. Does the Program Plan contain enough detail to minimize or eliminate administrative delays?

6. Has a maintainability figure-of-merit been established?

7. Has proper consideration been given to the quantification of maintainability in all planning and procurement documents?

8. Has consideration been given to continuous service requirements?

9. Has accessibility been optimized?

10. Has adequate accessibility been provided for antennas and microelectronic devices?

11. Are access doors within easy reach of the maintenance personnel?

12. Have sufficient and easily accessible test points been provided to enable the optimization of maintenance tasks?

13. Have the assemblies been standardized to ensure interchangeability?

14. Does the design consider ease of replacement, ease of identification, and ease of proper installation?

15. Can the hardware be easily removed and replaced?

16. Do the technical manuals contain troubleshooting techniques which have been developed concurrently with the system design?

17. Are the maintenance procedures and technical manuals clear, concise, and planned for delivery with the equipment?

18. Do the maintenance personnel have sufficient information to requisition replacement items?

MAINTAINABILITY
(Con'td.)

19. Have all maintenance personnel been adequately trained?

20. Have provisions been made to minimize turn-around-time?

21. Has routine paper work associated with maintenance been kept at a minimum?

22. Have all the anticipated overhaul schedules been listed?

23. Does the design allow for ease of inspections?

24. Has the requirement for special handling equipment been avoided?

25. Have weight and volume of replacement items been kept within reasonable limits?

26. Does the design consider storage environment, available storage space, and ease of storage?

27. Have the requirements for elaborate or sophisticated calibration equipment been eliminated or reduced?

28. Do the shop facilities have the personnel and equipment to permit the performance of the desired level of maintenance?

29. Have all potential maintenance and equipment hazards been identified and eliminated?

PRODUCT ASSURANCE

1. Has a receiving inspection program and procedure been developed for the vendors use as well as for in-house use?

2. Have inspection requirements and standards been established for parts?

3. Has an in-process inspection program, with sampl~~ing procedures~~ and inspection stations throughout the entire production process, been developed and implemented?

4. Have inspections for isolating faulty mechanical or soldered connections been established?

5. Have items been inspected for poor workmanship throughout the entire manufacturing process?

6. Has test equipment been inspected and tested to ensure good equipment quality and calibration?

7. Have items been inspected to ensure compliance with the required drawings and specifications?

8. Have drawings and specifications been examined for the latest issue and are they accurate and correct?

9. Does the procurement specification contain the correct specifications, drawings, and item requirements or standards?

10. Have steps been taken to ensure that all required tolerances and specifications have been met?

11. Has a Quality Control Plan been developed and implemented?

12. Have all the required drawings and specifications been included in the plan?

13. Has a Product Assurance Plan been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

14. Has a Vendor Surveillance Plan been developed and implemented?

15. Has the system development program been optimized to implement corrective action quickly?

16. Has a Configuration Control Program been developed and implemented?

17. Has the use of non-standard parts been avoided?

18. When non-standard parts must be used have provisions been made for the generation of non-standard part approval requests?

19. Have periodic quality audits been performed for ensurance of product quality?

20. Do all the purchase orders contain a detailed description of items to be purchased and their quality requirements?

21. Do test procedures include the desired tolerances, stress levels, and parameters?

TRAINING

1. Has a training program been developed which will properly train personnel to operate and maintain specialized equipment?

2. Has a Training Program Plan been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

3. Does the training program improve the operator and maintenance personnel training level?

4. Does the training program ensure the proper orientation of personnel in the maintenance and operations concepts of the particular system?

5. Has the latest up-to-date training material been selected to ensure personnel proficiency in their assigned areas?

6. What special training devices,(i.e., equipment and visual aides) are needed to ensure complete comprehension by personnel being trained?

7. Are the instructors well versed in the latest equipment maintenance and operation techniques, and are they qualified to teach at the levels desired?

8. Does the curricula adequately cover all training requirements?

9. Are the training procedures complete, correct, and easy to understand?

10. Will the training procedures be completed early enough to allow for an adequate supply and for timely delivery?

11. Are personnel being trained on equipment similar in complexity and operation to the equipment they will be operating and servicing in the field?

12. Are the training facilities adequately equipped for the number of personnel attending?

13. Will the training program produce trained personnel at an adequate rate?

DESIGN REVIEW

1. Does the design meet the required reliability and maintainability requirements?

2. Do all parts have a proven reliability characteristic, such as a low failure rate?

3. Can the use of non-standard parts be eliminated or reduced?

4. Have all part and component tolerances been determined?

5. Have the required parts characteristics been properly described in the specifications?

6. Have the limits of tolerance build-up been identified?

7. Have component parts been selected that meet the required operating and environmental loads?

8. Have the effects of transients been determined?

9. Have all the weight limitations been established for the various designs?

10. Have the effects of shock and vibration been considered?

11. Has a manufacturing process flow chart been developed?

12. Does the design necessitate re-tooling of production machinery?

13. Does the system design contain provisions of a back-up power supply and overload protection devices?

14. Are preferred circuits being used wherever possible?

15. Have adequate safety devices been provided throughout the equipment?

16. Is the equipment properly protected to ensure that adjustments and maintenance can be performed safely?

17. Have adequate cooling and ventilating capability been provided?

18. Have subcontract specifications been reviewed to ensure subcontract items are not over specified?

19. Are all equipment inputs and outputs compatible with the mission requirements?

20. Has a procedure for rapid implementation of corrective action been developed?

DESIGN REVIEW
(Con'td.)

21. Has the design been compared with similar designs, circuits, parts, or components to optimize the benefit of standardization and past experience?

22. Is the use of a design disclosure format feasible for the design review?

23. Has the frequency of the design review been decided?

24. Have the personnel to participate in the design review been designated?

25. Have design review requirements been integrated into the Systems Effectiveness Program Plan?

SAFETY

1. Has an antenna retarding device, which will prevent antenna movement while maintenance personnel are working on the antenna, been included in the design?

2. Have all the high voltage terminals been protected and covered?

3. Has all the system hardware been properly grounded?

4. Have all existing electrical and mechanical hazards been eliminated?

5. Has the use of special electronic devices which may be harmful to the working personnel been avoided?

6. Does all the system hardware have adequate safety devices, safety shields, and warning devices?

7. Have safety controls been provided on all system hardware?

8. Have personnel and equipment protection devices been employed on all system designs?

9. Has a safety analysis been performed in conjunction with a hazard analysis to point out potential safety hazards?

10. Have the results of the safety and hazard analyses been incorporated into the design review?

11. Have safety procedures been developed and implemented?

12. Have all design safety deficiencies been eliminated or reduced to acceptable limits?

13. Has a System Safety Engineering Plan been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

14. Does the system and its facilities contain adequate fire fighting equipment and fire alarms?

15. Do the system facilities contain adequate emergency exists?

16. Have emergency exists been properly marked?

17. Does the system contain adequate RFI protection?

LOGISTICS

1. Have precautions been taken to ensure that all technical, operational, maintenance, support, and illustrated parts breakdown documents are correct, and that they are supplied to the site personnel on time?

2. Has a procedure been developed to provide training and site personnel with updated copies of operational documents?

3. Have good packaging design criteria been used throughout the system design?

4. Has adequate packaging been provided to enable the item to survive transportation shock loads?

5. Has the hardware been properly protected against damage during transportation?

6. Has excessive transportation time been reduced by avoiding inadequate commercial transportation, poor roads, and storage areas that are too far from transportation?

7. Has the use of non-standard parts been avoided to the greatest extent possible?

8. Is there adequate storage facilities to handle system supplies and inventory?

9. Will all the equipment cases and packages be accurately and adequately marked to allow the use of proper materials handling equipment?

10. Has system turn-around-time been reduced, particularly in the area of spares?

11. Is there a sufficient supply of spares at the site?

12. Have several sources of supply been located to make special items less difficult to obtain?

13. Have other sources of supplies been located for parts that are no longer manufactured or stocked by the usual supply source?

14. Has the number of logistics personnel required to successfully operate the logistic phase of the system been established?

15. Have requisition procedures been developed which will require a minimum of change during implementation?

16. Have storage and marking procedures been developed which will thoroughly describe the steps to be taken when a particular item is being stored?

LOGISTICS
(Con'td.)

17. Will an accurate and up-to-date Inventory Control Program be initiated?

18. Will the lack of interchangeability in parts be considered when a supply area is being stocked?

19. Has the logistic supply system been designed to compensate for delays due to custom requirements?

20. Has logistic consideration been given to the special parts being used on certain equipment?

21. Has the maintenance philosophy been studied to enable the establishment of realistic logistic requirements?

22. Have the contractor maintenance philosophies been considered in the logistic supply system?

23. Has a Logistic Program Plan been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

24. Have all configuration management controls been developed and implemented?

25. Is an adequate purchasing staff being maintained and are standard purchasing procedures available to reduce purchasing delays?

TEST AND EVALUATION

1. Have all the test equipment and the test requirements been established?

2. Have all the calibration equipment been obtained and the calibration requirements determined?

3. Has a test schedule been established?

4. Have the system hardware items been subjected to environmental tests?

5. Have all storage and handling tests been performed?

6. Have all the necessary inspections been performed?

7. Have all the test specifications, test standards, and test procedures been reviewed for the purpose of identifying where simultaneous testing can be accomplished?

8. Have requirements for automatic test equipment or a computer test program been considered?

9. Has a Test and Evaluation Program Plan been developed, implemented, and integrated into the Systems Effectiveness Program Plan?

10. Have the Categories I, II, and III test requirements been adequately defined and implemented?

11. Have all acceptance test criteria been developed?

12. Have all acceptance tests been performed on the system?

13. Have all system test and evaluation criteria been developed?

ENVIRONMENT

1. Has the geographical locations of the system been surveyed in order to become familiar with inherent site location problems?

2. Have the effects of climatic variations on system performance been considered?

3. Has consideration been given to adverse conditions of terrain that may affect system performance?

4. Have the proper safeguards been implemented in order to limit the effects of temperature variations that may inhibit system performance?

5. Are proper techniques being employed to safeguard the system against sand and dust?

6. Have safeguards been instituted to limit the effects of excessive precipitation (rain, snow, and ice) on antennas, towers, and other structures?

7. Have proper methods and techniques been considered to reduce the effects of both natural and man made Electromagnetic Interference?

8. Has the effects of excessive winds on antennas, towers, and other tall structures been considered?

9. Have all possible problems, with regard to humidity effects on system performance, been avoided or eliminated?

10. Are the support facilities necessary to sustain system operation adequate and in proximity to system locations?

11. Are there good roads, airfields, shipping points, and other adequate transportation facilities in proximity to system locations?

12. Has consideration been given to all aspects of transportation problems, such as shock, vibration, packaging, temperature controls, etc., that may affect the system as it is being transported to its ultimate location?

13. Have adequate artifical environmental controls such as air conditioning, heating and ventilating been considered for all system storage, equipment, and personnel locations?

14. Have all possible problems regarding the corrosive effects of dissimilar metals been avoided or eliminated?

15. Has a maintenance philosophy and Logistic Program Plan been developed that is suitable to the needs of the system based on its location and other important environmental aspects?

16. Have all environmental considerations and requirements been integrated into the Systems Effectiveness Program Plan?

APPENDIX V

Requirements for a Systems Effectiveness Program

Requirements for a Systems Effectiveness Program
(For Ground Electronic Systems)

FOREWORD

The degree of Systems Effectiveness achieved in the development of a military system is dependent upon the management emphasis applied during all phases of system development. This document provides the criteria and guidelines that should prove valuable in developing systems effectiveness programs that will improve the effectiveness of systems and aid in mission accomplishment.

TABLE OF CONTENTS

1. SCOPE

1.1 Purpose. The purpose of this document is to establish uniform criteria for systems effectiveness programs and to provide guidelines for the preparation of a Systems Effectiveness Program Plan.

1.2 Application. This document and the approved Systems Effectiveness Program Plan will be used as the basis for the preparation of specifications, contract work statements, or other contractual documents by the procuring activity. Such documents shall conform to the requirements in this document in paragraph sequence, numbering, and headings. Where a paragraph is determined to be not applicable, subsequent subparagraphs will also be considered as not applicable. Applicable paragraphs will indicate any specific deviations or supplementary requirements. Subparagraphs may be added as required.

2. REFERENCED DOCUMENTS

2.1 List of Referenced Documents. The following documents are applicable to the development of a Systems Effectiveness Program Plan.

SPECIFICATIONS

MIL-E-4158	Electronic Equipment, Ground, General Requirements
MIL-T-4807	Tests, Vibration and Shock, Ground Electronic Equipment, General Requirements for
MIL-E-4970	(USAF) Environmental Testing, Ground Support Equipment
MIL-E-5272	Environmental Testing Aeronautical and Associated Equipment
MIL-E-6051	Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapons System
MIL-Q-9858	Quality Program Requirements
MIL-M-22436	Modular Assemblies, General Specification for
MIL-T-26673	Test Program for Equipment, Contractor Established
MIL-A-26669	Acoustical Noise Tests Aeronautical and Associated Equipment
MIL-H-27894	Human Engineering, Requirements for Aerospace Systems and Equipment
MIL-S-38130	Safety Engineering of Systems and Associated Subsystems and Equipment, General Requirements for
MIL-V-38352	Value Engineering Program Requirements

STANDARDS

MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-188	Military Communications System Technical Standards
MIL-STD-210	Climatic Extremes for Military Equipment
MIL-STD-415	Test Points and Test Facilities for Electronic Systems and Associated Equipment Definitions for Maintainability Engineering
MIL-STD-446	Environmental Requirements for Electronic Component Parts
MIL-STD-454	Standard General Requirements for Electrical Equipment
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments)
MIL-STD-471	Maintainability Demonstration
MIL-STD-721	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety
MIL-STD-756	Reliability Prediction
MIL-STD-778	Definitions for Maintainability Engineering
MIL-STD-781	Reliability Tests Exponential Distribution
MIL-STD-785	Requirements for Reliability Program (for Systems and Equipments)
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-803	Human Engineering Design Criteria for Aerospace Systems and Equipments, Part I Aerospace System Ground Equipment
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment
MIL-STD-826	Electromagnetic Interference Test Requirements and Test Methods

HANDBOOKS AND MANUALS

AFM 66-1	Maintenance Management
AFM 10-4	Guide for Air Force Writing
AFR 30-8	Personnel Subsystem Elements
AFR 74-6	Management of Quality and Reliability Assurance
AFR 80-5	Reliability Program for Systems, Subsystems and Equipments
AFR 7016	Value Engineering
AFLCM 66-11	Maintenance Quality Control Program
AFSCM 80-3	Handbook of Instruction for Aerospace Personnel Subsystem Designers
AFSCM 80-5	Handbook of Instructions for Ground Equipment Designers
AFSCM 80-6	Handbook of Instructions for Ground Equipment Designers
AFSCM 80-9	Handbook of Environmental Engineering
AFSCM 171-3	Quality Control Management Data
AFSCM/AFLCM 310-1	Volumes I and II Management of Contractor Data and Reports
AFSCM 375-1	Configuration Management During Definition and Acquisition Phases
AFSCM 375-2	Systems Program Management Surveys (SPMSs) and Industrial Management Assistance Surveys (IMASs)
AFSCM 375-3	System Program Office Manual
AFSCM 375-4	System Program Management Procedures
AFSCM 375-5	System Engineering Management Procedures
AFSCR 375-6	Management, Acquisition, and Control of Technical Publications
AMCP 706-134	Engineering Design Handbook, Maintainability Guide for Design, Chapter 10 Environment
ANA Bulletin 445	Engineering Changes to Weapons, Systems, Equipment, and Facilities

HANDBOOKS AND MANUALS
(Continued)

ESDP 80-1	Guidance on Application of Value Engineering Principles to Electronic Systems
DCAS Exhibit 62-10	Quality Assurance Requirements for Systems Effectiveness
MIL-HDBK-217	Reliability Stress and Failure Data for Electronic Equipment
MIL-HDBK-472	Maintainability Prediction
NAVSHIPS 94501	Reliability Design Handbook
NAVSHIPS 94324	Maintainability Design Criteria Handbook
ESD-TDR-64-616	Handbook for Reliability and Maintainability Monitors

3. DEFINITIONS

3.1 List of Definitions

Acquisition Phase — peri ring which detailed design and development are carried out. Category Tests are conducte . Hardware in required quantities is procured.

Availability — a measure of the degree to which an item is in the operable and committable state at the start of the mission when the mission is called for at an unknown (random) point in time.

Capability — a measure of the ability of an item to achieve mission objectives given the conditions during the mission.

Communication — the discipline that provides control of the interchange of thoughts through either written or spoken messages.

Conceptual Phase — period in system development during which a feasible technical approach is developed for satisfying a given requirement.

Constituent Ability — a discipline related to the success of a mission.

Definition Phase — period during which the specific system configuration is selected and defined, performance schedules are established, and cost and schedule estimates are provided. The desirability of acquiring the system for use is confirmed.

Dependability — a measure of the item operating condition at one or more points during the mission, including the effects of Reliability, Maintainability, and Survivability, given the item condition(s) at the start of the mission. It may be stated as the probability that an item will: 1) enter or occupy any one of its required operational modes during a specified mission; and 2) perform the functions associated with those operational modes.

Design Review — the discipline that provides control of the critical examination of all elements that comprise a system with the objective of isolating areas where design improvement is required.

Environment — the combination of both man-induced and naturally caused conditions and circumstances under which a system may be operated.

Environmental Factor — a major condition or circumstance that exists at a location, such as: Climate, Temperature, Transportation, or Maintenance Philosophy.

Environmental Subfactor — variation that exists in an environmental factor, such as: Climate. Subfactors of climate are Frigid, Tropic, and Temperate.

Event — a subability or related factor.

Human Factors — the discipline that provides control of the application of scientific facts about human characteristics covering all biomedical and psychosocial considerations. Includes such items as human engineering and personnel selection.

Item — denotes any level of hardware assembly, i.e., system, segment of a system, subsystem, equipment, component, part, etc.

Logistics — the discipline that provides control of effective and economical supply to a system at all levels of maintenance throughout a system's programmed life cycle.

Maintainability — the discipline that provides the control necessary to ensure that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

Management — the discipline that provides control over the development and application of resources to accomplish predetermined objectives.

Man Induced Environment — man made or man caused conditions or circumstances such as transportation, storage, handling.

Mission — the objective or task, together with the purpose, which clearly indicates the action to be taken.

Natural Environment — naturally caused conditions or circumstances such as, climate, temperature, humidity.

Operational Phase — period in which the procured system is employed in an effective manner. (Operational Phase overlaps the Acquisition Phase.)

Personnel — the discipline that provides control of human elements necessary in the operation, maintenance and support of a system in a specified environment.

Product Assurance — the discipline that provides control of materiel in order to provide adequate confidence that materiel conforms to the composite of established standards.

Program Planning — the discipline that provides control of an organized approach which specifies milestones, schedules, goals, and the means by which to reach these goals.

Related Factor — an event that must be performed for the distinct purpose of assuring that a certain goal be achieved. A related factor is indirectly related to a Constituent Ability.

Reliability — the discipline that provides the control necessary to ensure that an item will perform its intended function for a specified interval under stated conditions.

Safety — the discipline that provides control of the conservation of human life and its effectiveness, and the prevention of damage to items, consistent with mission requirements.

Subability — an event that must be performed for the distinct purpose of assuring that a certain goal be achieved. A subability is directly related to a constituent ability.

Support — the discipline that provides control of the physical, on site items that are required for normal system operation.

System Performance — the discipline that provides control of the execution of required functions in a system as demonstrated by major operational parameters.

Systems Effectiveness — a measure of the degree to which an item can be expected to achieve a set of specific mission requirements, and which may be expressed as a function of availability, dependability, and capability.

Test and Evaluation — the discipline that provides control of critical examination of items to determine the acceptability of the items.

Training — the discipline that provides control of teaching personnel new information, techniques, and concepts.

4. GENERAL REQUIREMENTS

4.1 Systems Effectiveness Program. The Systems Effectiveness Program is the responsibility of the systems effectiveness activity within an organization. The program shall

be planned, integrated, and developed in conjunction with other planning functions. The program shall be planned to meet systems effectiveness objectives and minimum acceptable qualitative and quantitative requirements. These requirements are as indicated in the Request for Proposal and as agreed to in final negotiations. Quantitative requirements shall be expressed as a Systems Effectiveness Figure of Merit (FOM).

The program, for all project phases, shall provide for periodic refinement of the systems effectiveness FOM. Progressive systems effectiveness levels, either qualitative or quantitative, that can be assessed at the scheduled program review points shall be established for each major phase of the project.

The program shall be developed to suit the type of procurement, and shall be based upon such factors as the complexity of the design, the quantity under procurement, and the manufacturing techniques required. The program shall ensure adequate systems effectiveness consideration throughout all aspects of the conceptual, definition, acquisition, and operational phases of system development.

4.2 Systems Effectiveness Program Plan. Systems Effectiveness can be improved through the proper development and implementation of a Systems Effectiveness Program Plan. Many events must take place during system development to improve Systems Effectiveness. The required events (subabilities and related factors) are identified and categorized under fourteen Constituent Abilities or major disciplines. Various types of effort that occur in each event contribute to the improvement of the associated Constituent Ability and in turn improve Systems Effectiveness. The fourteen Constituent Abilities are:

Management	Maintainability
Communication	Product Assurance
Program Planning	Training
Personnel/Human Factors	Design Review
System Performance	Safety
Support	Logistics
Reliability	Test and Evaluation

In addition to the fourteen Constituent Abilities presented above, environments also impact significantly on effectiveness. Environments have been categorized into environmental factors and environmental subfactors.

The Systems Effectiveness Program Plan shall provide an overall systems effectiveness approach for the activity responsible for integrating their respective disciplines and environmental considerations.

The plan must describe an integrated systems effectiveness effort within the total project and shall provide specific information to show how the contractor will meet specified qualitative and quantitative systems effectiveness requirements during design, development, and manufacture, including design concepts to be utilized. The methods for predicting and demonstrating systems effectiveness shall be described. Coordination of effort throughout the development and implementation of the plan must be stressed to ensure an integrated approach to systems effectiveness.

Meeting the requirements for an integrated Systems Effectiveness Program Plan, will result in the following:

1. A schedule of tasks developed and oriented towards more effective management of the development of ground electronic systems.

2. A plan which aids in the application of events to a specific depth.

3. A plan that ensures application of events in specific functional activities (e.g., Systems Analysis/Systems Engineering) to the appropriate depth during the most appropriate phase of development and in order of importance according to the impact of these events on Constituent Abilities.

4. A plan that shows commonality of Constituent Abilities during the development of a ground electronic system. Although a Constituent Ability may be common to more than one functional activity, the events, the order of these events and the applicable phase of each event may vary according to the functional activity under consideration.

5. A plan that identifies significant environmental factors and subfactors and includes guidelines which eliminate or tend to minimize the effects of environments on Systems Effectiveness.

The proposed program plan, in accordance with this document, shall be submitted as a separate entity within the total ground electronic system. The Systems Effectiveness Plan, as approved by the procuring activity and incorporated into the contract, becomes the basis for contractual compliance.

5. DETAILED REQUIREMENTS

5.1 Program Plan Elements. The Systems Effectiveness Program Plan shall contain a description of the following systems effectiveness elements.

5.1.1 Systems Effectiveness Organization. The plan shall: 1) identify the activity within the organization and the key personnel responsible for managing the overall Systems Effectiveness Program; and 2) clearly define the responsibilities and functions of the personnel directly associated with systems effectiveness policies and implementation. It shall specify the authority delegated to this activity to enforce its policies. The relationships between line, service, staff, and policy organizations shall be identified.

5.1.2 Determination of Relationships Between Constituent Abilities and Activities. The fourteen Constituent Abilities listed in paragraph 4.2 shall be applied to the system under development. The functional activities responsible for each of the fourteen constituent abilities shall be identified. A chart, similar to the one in TR- , Figure 2 Relationships of Constituent Abilities to a Typical Functional Organization Responsible for System Development, shall be prepared to present the relationships of the fourteen Constituent Abilities to the specific functional activities that were identified previously. The chart will result in a presentation of the commonality of certain Constituent Abilities.

5.1.3 Determination of Events for Each Constituent Ability. All events (subabilities and related factors) applicable to each of the fourteen Constituent Abilities (major disciplines) listed in paragraph 4.2 shall be determined. The compliment of events will vary for each type of system, however, all fourteen disciplines shall be considered in all system development programs. Refer to TR- , Appendix III Relationship of Constituent Abilities and Related Factors to Functional Activities, which presents the events that are applicable to the disciplines shown in Figure 2 for a typical organization.

5.1.4 Establishment of Required Effort For Each Event. The type of effort that is required to implement each event, such as analysis or evaluation, shall be established. The type of effort will aid in delineating the specific responsibilities that each functional activity has with respect to each event. Refer to TR- , Appendix III Relationship of Constituent Abilities and Related Factors to Functional Activities, which presents events and the corresponding type of effort that is required for each event for the typical organization shown in Figure 2.

5.1.5 Establishment of Priority For Each Event. The importance of each event in relation to the Constituent Ability and functional activity responsible for the event shall be established in priority sequence. The effort for each event shall be implemented, during system development, according to the established priority to ensure improvement in each Constituent Ability to which each event is related.

5.1.6 Establishment of Appropriate Phase For Each Event. The phase of development in which each event should be applied to ensure timely application of the events to a system shall be established. Refer to TR- , Appendix III Relationship of Constituent Abilities and Related Factors to Functional Activities, which presents events and the phase in which each event should be applied for the typical organization shown in Figure 2.

5.1.7 Identification of Environments For Operating Systems. All possible environments in which the system will be required to operate shall be identified in terms of both man induced and natural environmental subfactors. Refer to paragraph 7 in TR- for the approach to be used in identifying environments.

5.1.8 Determination of Effects of Environmental Factors and Subfactors on the System. The relationships of environmental factors and subfactors to environmental effects shall be determined. Refer to TR- , Figure 7 Relationships of Pertinent Environmental Factors and Subfactors to Environmental Effects, which presents the effect of particular environmental factors and related subfactors on system. Table 2 Relationships of Pertinent Environmental Factors and Subfactors to Environmental Effects to System Performance and to Performance Characteristics, presents the effect of particular environmental factors and related subfactors on system performance and system performance characteristics.

5.1.9 Integrate Abilities and Environments That Impact on Systems Effectiveness. The abilities and environments that have been considered significant for a system shall be integrated with respect to time. Abilities and environments shall be considered on a timely basis to ensure improvement in each Constituent Ability which in turn, results in an improvement in Systems Effectiveness.

5.1.10 Systems Effectiveness Management and Control. The Systems Effectiveness Program Plan shall include:

1. Detailed listings of specific tasks and procedures to implement and control these tasks.

2. A current description of each task to be performed whether or not it is already documented in existing directives.

3. The method of control to ensure execution of each task as planned.

4. Scheduled start and completion dates of each task.

5. Procedures for determining specific tasks to be performed as a basis for achieving the proper balance of effort and resources from a systems effectiveness standpoint.

6. Allocation of quantitative requirements for applicable Constituent Abilities.

7. Identification of known technical problems to be solved.

8. An assessment of the impact of technical problems on specified program requirements.

9. Detailed proposed solutions to technical problems and a program to solve the problems.

10. Procedures for recording status of actions to resolve technical problems.

11. Method of dissemination of the systems effectiveness requirements to designers and associated personnel to expedite correction of known deficiencies.

12. Designation of milestones, definition of inter-relationships, and estimation of times required for systems effectiveness program activities and tasks (where PERT is used in the total program, appropriate systems effectiveness milestones shall be included in the overall network).

13. Periodic status recording of predicted and achieved systems effectiveness.

5.1.11 Systems Effectiveness Program Review. The systems effectiveness program shall be planned and scheduled to permit the contractor and the procuring activity to review its status, including results achieved, at pre-planned steps or check points. This formal review and assessment of Systems Effectiveness shall be conducted at major program points including PDR's, CDR's, and FACI, and such other points as established by the procuring activity during negotiations. Systems effectiveness progress shall be assessed by the use of systems effectiveness reviews as the project develops. The systems effectiveness reviews shall be conducted in conjunction with the planned system project reviews to ensure an integrated approach to Systems Effectiveness.

5.1.11.1 Notification of Program Review. The procuring activity shall be notified at least 10 days prior to each contractually scheduled formal systems effectiveness program review to permit possible participation by the procuring activity. The minutes of these formal systems effectiveness program reviews shall be made available to the procuring activity upon request.

5.2 Integrating Systems, Subsystems and Equipment Hardware. Where other hardware, such as government-furnished equipment, are to be integrated with the system under development, potential systems effectiveness problems caused by newly introduced government-furnished hardware shall be identified. System changes necessary to accommodate their use or the improvement necessary to make this hardware compatible with the requirements of the system under development shall be justified.

6. NOTES

6.1 Intended Use. In the use of this document each of its paragraphs shall be considered by the procuring activity for applicability of, deviations to, or supplementary requirements for each paragraph (see paragraph 1.2). Attention is directed to the following:

a. Quantitative Systems Effectiveness Figure of Merit (see paragraph 4.1).

b. Approval and deviations from any proposed Systems Effectiveness Program Plan (see paragraph 4.2).

c. Milestones at which contract compliance is to be demonstrated and at which systems effectiveness demonstration plan is to be submitted (see paragraph 5.1.10).

d. Pre-planned program review check points, if any (see paragraph 5.1.11).

e. Itemization of government-furnished hardware which is to be integrated to provide a complete operational system (see paragraph 5.2).

6.2 Data Requirements. The selected data requirements in support of this document shall be reflected in a contractor proposed Data Requirements List attached to the request for proposal, invitation for bid, or the contract as appropriate. (Refer to AFSCM/AFLCM 310-1).

Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

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13. ABSTRACT The achievement of optimum Systems Effectiveness in the operational environment is dependent on the proper consideration and implementation of a number of events, starting from the very conception of the system and then proceeding through the acceptance of the system in the field. A need existed for the development of an organized approach which could be used as the basis for ensuring that these events are adequately considered and performed on a timely basis.

The study described herein was undertaken for the purpose of identifying those events which influence Systems Effectiveness and the determination of the relationships of these events. This information was organized in a manner which provides cognizant personnel with the criteria necessary for achieving optimum Systems Effectiveness. Major emphasis was placed on criteria relating to the design of systems since this is the area in which the majority of events influencing Systems Effectiveness must be implemented. However, events associated with system development, production and acceptance were also considered since they have a direct impact on operational effectiveness.

An integral part of this report is the Requirements for a Systems Effectiveness Program. These requirements, based on the entire Systems Effectiveness study, provide uniform criteria for the development of Systems Effectiveness Programs and provide a model for the preparation of Systems Effectiveness Program Plans.

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